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Understanding Patterns of Innovation within the UK Milk Production Sector

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Submitted in accordance with the requirements for the degree of
Doctor of Philosophy
Science Policy Research Unit University of Sussex

January 2019

I hereby declare that this thesis has not been and will not be, submitted in whole or in part to another University for the award of any other degree.

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Doctor of Philosophy in Science and Technology Policy

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ABSTRACT

This thesis examines patterns of technological change in the UK dairy farming sector between 1994 and 2016. It aims to illuminate the extent to which, and ways in which, powerful buyers, such as supermarkets, have influenced observed trends of market concentration and production intensification in dairy farming within value chains for liquid milk.

By applying an evolutionary perspective, the thesis considers both the rate and the direction of technological change. Dairy farms are regarded as ‘socio-technical systems’ that can be ‘reproduced’ in a ‘dynamically stable’ manner. Positive feedbacks resulting from interactions between systems’ components serve to stabilise reproduction, while interactions between different groups of actors present opportunities for disruption of the process of reproduction. The analysis draws upon conceptual tools from the literatures on value chain analysis (‘sanctions’ and ‘trust’) and the social construction of technology (‘framings’) in order to permit an exploration of reproduction as an inherently-contested process of ‘negotiation’. This analytical approach may have wider application within other agricultural and non-agricultural value chains, characterised by powerful – or oligopolistic – buyers.

Through an in depth case study analysis of 16 UK dairy farms – and a quantitative analysis of a broader dataset of over 350 UK dairy farms – key patterns of technological change are revealed. The intensification and homogenisation of production amongst farms that supply supermarkets directly is attributed to: the degree of price variation within the market (with supermarkets paying considerably higher, more stable prices than other buyers); the higher degree of ‘trust’ that exists within supermarket value chains, resulting in longer, more collaborative relationships (compared with the value chains of other buyers); and the practice of benchmarking within supermarket supplier pools (often undertaken by reference to production costs). Significantly, these factors have both a *direct* influence upon the production approaches of farms that supply supermarkets, and an *indirect* influence on other farms, suggesting that the influence of supermarket power may be more pervasive than implied by previous analyses.

Furthermore, the findings also call into question the long-run sustainability of supermarket value chains, as currently constituted, in the face of biological and economic shocks and stresses.

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LIST OF ACRONYMS

£PLI	Profitable Lifetime Index
AHDB	Agricultural and Horticultural Development Board
AI	Artificial insemination
BVD	Bovine viral diarrhoea
CAP	Common Agricultural Policy
CIS	Community Innovation Survey
CIWF	Compassion in World Farming
DCD	Dairy Crest Direct
Defra	Department for Environment, Food & Rural Affairs
DM	Dry matter
EEC	European Economic Community
EFRA	Environment, Food and Rural Affairs Committee
EFSA	European Food Safety Authority
EU	European Union
FAO	UN Food and Agriculture Organisation
GAECs	standards of good agricultural and environmental conditions
GB	Great Britain
GCA	Groceries Code Adjudicator
GSCOP	Groceries Supply Code of Practice
GHG	Greenhouse gas
GVA	Gross value added
GVC	Global value chains
HYV	High yielding variety
Kg/DM	Kilogrammes of Dry Matter
MMB	Milk Marketing Board
PCA	Principal Component Analysis
ppl	Pence per litre
RABDF	Royal Association of British Dairy Farmers
RMS	Recycled manure solids
SCC	Somatic cell count
SCOT	the social construction of technology
SMP	Skimmed milk powder
SMRs	statutory management requirements
SPS	Single Payment Scheme
TB	Tuberculosis
TMR	Total mixed ration
TSDG	Tesco Sustainable Dairy Group
UK	United Kingdom of Great Britain and Northern Ireland
WSPA	the World Society for the Protection of Animals

Chapter 1:

Introduction

This thesis aims to identify the extent to which, and ways in which, powerful buyers, such as supermarkets, influence technological change amongst their suppliers. These issues will be examined through a study of the value chain for liquid milk in the United Kingdom (UK), which will: characterise patterns of technological change exhibited by UK dairy farms; ascertain the influence of buyers' demands upon such patterns (as distinct from other influences); and determine the mechanisms through which such influence is secured. The findings of this study will suggest policy recommendations regarding the future of the UK dairy sector, which has recently been a source of considerable debate (see below, **Section 1.1**).

Although it is based upon an examination of the UK dairy farming sector, the study aspires to make a broader contribution to theories of technological change and power, which may be applied to the understanding of similar processes within other sectors of the economy, in particular those that are characterised by the concentration of power amongst a small number of large organisations. Such processes are of particular relevance given the globalised nature of the modern economy, the prominent role played by multinational corporations within it, and the potential consequences of this for prosperity, equality, and sustainable development (Crotty et al 1998; Gereffi et al 2001).

1.1 Background

The impact of retail market concentration upon the food and agriculture sector has emerged as a subject of considerable public interest. It is often suggested that, due to their power, supermarkets are able to capture a disproportionately large share of the retail price of food products, therefore exerting significant pressure upon suppliers and producers upstream. Because larger, more intensive producers may be better able to withstand such market conditions (Lang & Heasman 2004) the concern is that supermarket power may contribute towards a homogenisation and intensification of production, and a corresponding lack of diversity (and resilience) across the agricultural sector, with potentially negative consequences for environmental, economic and/or social sustainability.

Within the UK dairy farming sector, specifically, repeated crises have prompted a debate regarding the nature of the relationship between technological change in dairy farming (an intensification in production) and ongoing structural changes within the dairy farming sector (a

reduction in farm numbers and an increase in farm sizes) as well as within the wider value chain for milk (a concentration within the processor and retailer markets; see **Section 2.2**).

On the one hand it could be that supermarkets have driven a process of intensification in UK dairy farming, through their engagement in successive rounds of 'price wars', and through the use of milk as a 'loss leader' (House of Commons 2004, Ev34); practices that have depressed the farmgate price of milk, meaning that only the largest, most intensive farms, benefitting from economies of scale, have been able to survive. On the other hand, a 2012 analysis by the Agricultural and Horticultural Development Board (AHDB) implied that the ongoing viability of UK dairy farms is not reliant upon the widespread adoption of an intensive, large scale production model, but that "... milk can be produced efficiently from any of the major systems that are currently practised ... [and] moreover, efficient milk production is possible at almost any scale of production" (DairyCo 2012a, p.4). By implication, it may be that the intensification of dairy farming has not been a response to market conditions, but is merely the continuation of a longer-running trend towards fewer, larger, more productive farms (Empson 1998, p.78) due to incremental improvements in farming technologies, including advances in genetics, veterinary science, and agronomy (Brassley 2000; Bieleman 2005; Lampe and Sharp 2015).

Given the strong – often competing – interests and perspectives of the various contributors to this debate, there is a risk that discussions regarding the future direction of the dairy sector may become increasingly polarised, with views on either side being reduced to simplified, "linear" accounts of change (Brooks et al 2009). Such accounts were exemplified by a 2013 strategic report by the National Farmers Union (NFU), which proposed that the UK dairy farming sector should respond to recent challenges through a narrow focus upon efficiency improvements, aimed at increasing the UK's milk production in order to compete within emerging markets for dairy products, such as China (NFU 2013; see **Section 2.3.1**).

Rather than viewing observed changes in the dairy sector as the uniform response of a single dependent variable (i.e. technological change) to the action of a single independent variable (e.g. 'buyer power' or 'scientific advances'), this thesis aims to enrich the debate by providing an alternative perspective to such linear accounts. In so doing, it hopes to offer a more nuanced understanding of the processes described above and, accordingly, a more useful set of policy recommendations.

1.2 Thesis Structure

In order to explore the issues introduced above, this thesis will begin, in **Chapter 2**, by describing in greater detail the economic, social and environmental context within which the debate surrounding the UK dairy farming sector is currently situated.

Chapter 3 will review a range of theoretical perspectives that have been applied within studies of innovation and technological change across a range of sectors, including agriculture. Theoretical approaches to power and its role within value chains for agricultural products will also be reviewed. This will contribute to the development a theoretical foundation upon which to construct a framework for analysing the influence of buyer power upon processes of technological change within UK dairy farms, which will be outlined in **Chapter 4**.

Chapter 5 will provide an overview of dairy farming technologies and of the actors and governance conditions within the UK value chain for liquid milk. This will delineate the elements that will be included within the analysis and how the analytical concepts discussed in **Chapter 4** will be applied. This overview will also serve to 'bound' the study, forming a basis for the data collection and case study approach that will be adopted in this study, which will be described in greater detail within **Chapter 6**.

The results of the analysis of these case studies will be summarised in **Chapters 7, 8 and 9**. These findings, and the ways in which they serve to answer the research question, will be discussed in greater depth in **Chapter 10**, which will also enumerate the knowledge claims made within this thesis and provide an account of the strength, limits and generalisability of these claims. **Chapter 11** will conclude with an overview of the empirical contributions made in this study, the predictions and policy implications associated with these findings and their broad contributions to theory, reflections on the methodology adopted within the study, and areas for further research.

Chapter 2: Policy Context

This chapter provides a high-level summary of the economic, social and environmental context within which the debate regarding recent and possible future trends in the UK dairy farming sector is situated, and within which policy is formulated. It first outlines the economic, social and environmental significance of UK dairy farming, before considering trends and structural changes in the sector between 1994 and 2016. Finally, it highlights the potential economic, social and environmental implications of a continuation of these trends.

The purpose of this summary is not to propose explanations of how this set of conditions has emerged, nor to offer predictions of the future based on current conditions. Neither does it aim to critically examine current policy approaches. Instead, the intention is to provide an indication of the importance of the issues that this thesis is centred around, and to which it aims to contribute.

2.1 Dairy Farming: Economic, Social and Environmental Significance

2.1.1 Economic Significance

The significance of dairy farming to the UK economy demonstrates the importance of understanding the future shape and direction that the sector may take. In 2011 dairy farming was “the single largest agricultural sector in the UK”, accounting for 16% of UK agricultural production by value (House of Commons 2013, p.4). In 2016, the total value of milk produced in the UK was £3,296m. This was greater than the total value of poultry meat produced (£2,246m), and just over a quarter of the total value of the output of all UK livestock (£12,686m; Defra 2017a, p.31-32).

Total UK milk production for the year 2015/6 was 14,829m litres (AHDB 2016, p.18), making it the third largest producing country in the European Union (EU) after Germany and France (ibid. p.20). In 2013 the UK was the tenth largest producer of milk in the world (ibid. p.22).

Out of the total volume of milk produced in the UK in 2015, 6,856m litres were directed towards the liquid milk market, and 7,419m litres were allocated for the manufacture of dairy products. Although this study is focused on the agricultural production of liquid milk for drinking, raw milk produced by UK dairy farms serves as a significant material input into the broader dairy products manufacturing sector, the gross value added (GVA) of which was £2bn in 2015 (compared with the largest UK manufacturing sector – beverages – which had a GVA of £6.6bn

in 2015; Defra 2017b, p.12). A robust dairy farming sector is of strategic significance to the UK's trade balance for dairy products (of which more below, 2.3.1).

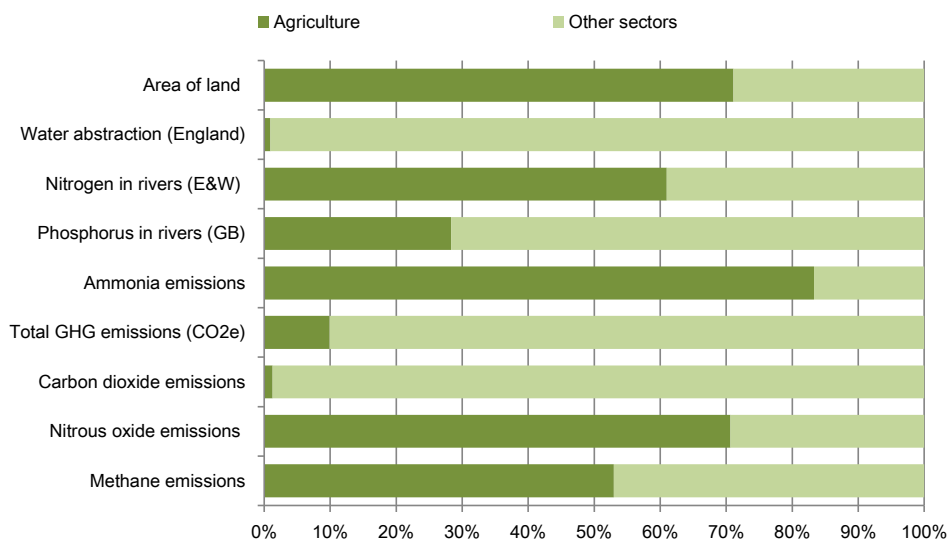
2.1.2 Social Significance

In 2016, 26,256 individuals were estimated to have been employed in the dairy farming sector in England alone.¹ Because it is generally less exposed to seasonal fluctuations in labour demand than many other agricultural sectors (such as, for example, horticulture), dairy farming relies relatively less upon "seasonal unskilled" labour and more upon individuals in permanent or full time employment, who can provide "24-7 attention year-round, relatively high levels of skill and an acquired knowledge of the farm and animals" (RABDF 2017, p.4). Out of those working in dairy farming in England in 2016, 11,188 were reported to be full time farmers, partners, directors and spouses; 3,978 were part time farmers, partners, directors and spouses; and 5,681 were regular full time workers.

2.1.3 Environmental Significance

Agriculture – and the farming of livestock in particular – has a profound impact upon the environment (see **Figure 2a**). Indeed, in 2006, the UN Food and Agriculture Organisation (FAO) concluded that the livestock sector is "one of the top two or three most significant contributors to the most serious environmental problems, at every scale from global to local" (UN FAO 2006, p.xx).

Figure 2a: Environmental Footprint of UK Agriculture



Source: Defra (2017a), p.79

¹ <https://www.gov.uk/government/statistical-data-sets/structure-of-the-agricultural-industry-in-england-and-the-uk-at-june>

With regard to the UK dairy farming sector, a lifecycle analysis of the impacts associated with a single litre of milk – from production, to processing, packaging, retailing, final consumption, and transportation between each of these stages – suggested that “agricultural production contributes the largest proportion of environmental impacts for most environmental themes” (Foster et al 2007, p.vii). According to the Department for Environment, Food & Rural Affairs (Defra), key environmental impacts of dairy farming in England include (Defra 2012, p.36):

- Loss of biodiversity due to intensive grassland and maize management
- GHG emissions, including methane, nitrous oxide, carbon dioxide
- Water pollution by nitrates, phosphates, coliform bacteria, silt, pesticides and veterinary residues
- Biodiversity loss and GHG emissions arising from forest and savannah conversion driven by the use of soy and palm derived feedstuffs from the tropics and South America
- Soil structural degradation
- Nitrification leading to biodiversity loss and acidification as a result of atmospheric ammonia emissions
- Water use in areas and periods of high water stress
- Depletion and pollution of ground and surface waters by remote feed and fodder production
- Use of GM crops in dairy feed.

2.2 Structural Changes in the UK Dairy Sector 1994-2016

Structural changes to the dairy sector since the abolition of the Milk Marketing Board (MMB) in 1994 – with regard to farming, processing and retailing – can be summarised as:

- A reduction in farm numbers, an increase in average herd size, and an increase in the volume of milk produced per cow
- A concentration in processor market
- A concentration in the retail market, accompanying a shift by consumers from doorstep delivery to supermarket purchase of milk.

This section outlines these trends in greater detail.

2.2.1 Concentration in Production

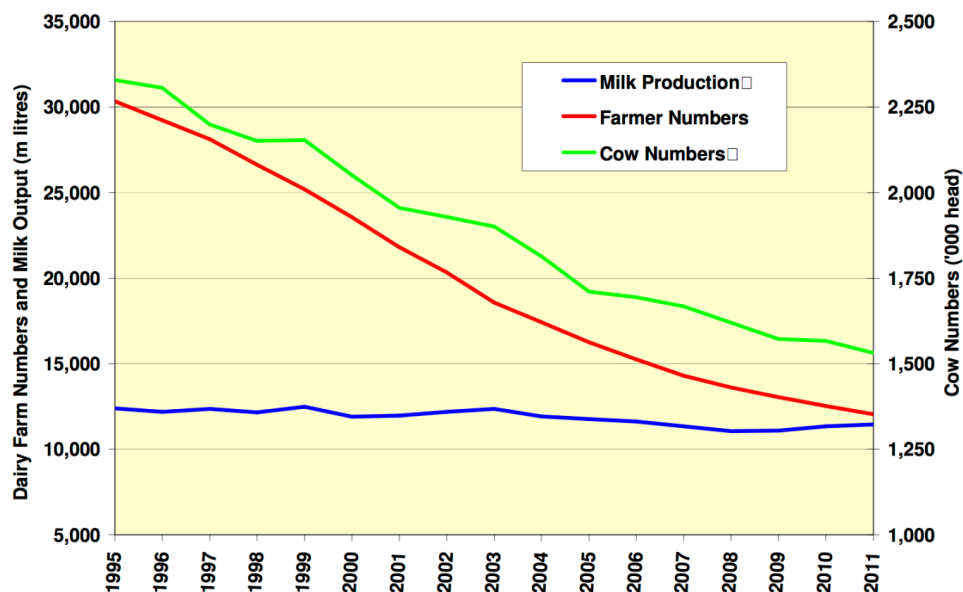
Since 1994 there has been a concentration in the UK dairy farming sector. Farm numbers declined steadily after the MMB was dissolved, more than halving between 1995 and 2010, from

35,741 to 15,716 (Hawkins 2011, see also **Figure 2b**). In 2016 there were 13,227 dairy farms operating in the UK² and UK dairy farm numbers were reducing at a rate of 2.5% year-on-year.³

The total number of dairy cows in the UK also declined post-1994, showing a 27% reduction from 2.6m in 1996 to 1.9m in 2015 (Bate 2016, p.3), with cow numbers remaining at 1.9m for 2016 (Defra 2017a, p.14). The decline in the overall number of cows has been less pronounced than the reduction in farm numbers, meaning that average herd sizes (i.e. cows per farm) increased across the period 1996 to 2016 from 75 to 143.

Despite the reductions in farm numbers and overall cow numbers, total UK milk production levels increased between 1994 and 2016 due to considerable increases in milk yields per cow (Hawkins 2011). In 1994/5 the total milk produced in the UK was 13,755m litres, rising to 14,829m litres in 2015/16.⁴ Average yields per cow⁵ in 1995/6 were 5,512 litres per cow, rising to 7,942⁶ litres per cow in 2015/16.

Figure 2b: Trends in GB dairy sector 1995 to 2011



Source: DairyCo 2013a, note: figures exclude Northern Ireland

² <https://dairy.ahdb.org.uk/market-information/farming-data/producer-numbers/uk-producer-numbers/> accessed 15/3/18

³ <https://dairy.ahdb.org.uk/resources-library/market-information/farming-data/producer-numbers/> accessed 16/3/18

⁴ <http://dairy.ahdb.org.uk/resources-library/market-information/supply-production/monthly-milk-production/#.WqpV6BTmz5o>

⁵ <https://dairy.ahdb.org.uk/resources-library/market-information/farming-data/average-milk-yield/>

⁶ provisional figure

The net result was that, compared with 1994, in 2016 there were fewer, larger dairy farms, producing more milk per cow.

This development represents the continuation of a longstanding trend towards fewer, larger, higher output herds. For example, in 1940 there were some 138,490 registered producers of milk in England and Wales, with an average of just 15 cows per herd and annual yields of 2,355 litres per cow (Empson 1998, p.78).

2.2.2 Concentration in the Processor Market

Prior to the UK's accession to the European Economic Community (EEC), the UK dairy sector was largely protected from international competition, with the MMB providing a guaranteed milk price for farmers. Post-accession, trade restrictions within Europe were reduced and, ultimately, abolished. The MMB proved incompatible with the European Union (EU) regime (Empson 1998) and was dissolved in 1994.

Before 1994, the UK dairy sector was effectively "state regulated", with the MMB purchasing all milk and acting as "the monopoly broker of milk between producers and processing companies" (Banks and Marsden 1997, p.386). The abolition of the MMB therefore represented a substantial loss of economic power for farmers in favour of private sector milk buyers. Post-1994, processors such as Robert Wiseman seized the opportunity for expansion offered by market liberalisation, as farmers were no longer required to sell to the MMB. Large brokers at the time included the Milk Group and United Milk Producers, which later developed processing capacity as United Milk (subsequently going into receivership).

Since 1994, the processor market has come to be dominated by a small number of large players: in 2011/12 the seven largest milk buyers purchased 80% of milk produced in the UK (DairyCo 2013b, p.4).

In the period since 2011 there has been further consolidation in the market. In 2012, major processor Arla Foods and dairy co-operative Milk Link merged, and Müller UK (part of the German based Müller Group) purchased Robert Wiseman (then one of the largest UK processors). The result was that Arla and Müller UK had "an estimated combined raw milk requirement of just under half (48%) of Britain's 11.5bn litres annual milk production" (DairyCo 2013b p.4). In 2015, further consolidation took place as Müller purchased Dairy Crest's dairy business, with 660 farmers transferring their supply from Dairy Crest to Müller in the process.⁷ Processors are now regarded as the 'gatekeepers' to the UK milk market.⁸

⁷ <https://www.fginsight.com/news/news/name-change-for-Müller-wiseman-as-dairy-crest-deal-completed-8918>

2.2.3 Concentration in Retail Market and Changes in Consumer Practices

Whereas doorstep delivery had dominated the market for liquid milk during the days of the MMB (Banks and Marsden 1997, p.392), market liberalisation accompanied a change in consumers' purchasing habits. In 1980, "doorstep deliveries still accounted for 89% of household sales of milk" (Dewick and Foster 2011, p.4). By 1995, doorstep delivery accounted for 45% of the retail milk market, and by 2015 this had declined to just 3% of the market by volume (Bate 2016, p.3; AHDB 2015, p.60), with shoppers choosing to purchase milk from supermarkets instead.

According to a 2011 report from the Environment, Food and Rural Affairs Committee (EFRA), "Liquid milk retail is concentrated in supermarkets, which account for 85% of sales" (House of Commons 2011, p.7). At the time of writing, it is possible that this proportion is even higher, as the same report suggested that doorstep delivery accounted for 7% of sales.

2.3 Potential Implications of, and Policy Responses to, Observed Trends

2.3.1 Potential Economic Implications

The current economic predicament of the dairy farming sector was summarised above (2.1). Potential economic implications of future patterns of development are broad and varied. However, much recent attention has focused upon the possible impacts upon the UK trade balance for dairy products.

The UK currently operates a trade surplus in raw milk and milk powders, albeit a larger trade deficit for manufactured dairy products (in particular cheese; see **Table 2a**). With farms exiting the sector at a high rate (see above, 2.2) some have expressed concerns that, over the longer term, this may result in a reduction in total UK milk production, which might incur increased trade deficits as domestically-produced milk currently destined for the domestic manufacturing sector may be redirected instead to the domestic liquid market. For example, the RABDF has suggested that "with UK self-sufficiency for dairy products at only 77% and ambitions from New Zealand and Ireland among others to increase their exports to the UK, a decline in domestic dairy production ... could lead to long-term displacement of domestic production from imports." (RABDF 2017, p.4)

⁸ Personal communication, DairyCo representative 2 December 2014

Table 2a: UK Dairy Trade Balance

		Imports	Exports
Raw milk (millions of litres)	2013	187	501
	2014	185	586
	2015	185	586
Butter ('000 tonnes)	2013	106	45
	2014	95	51
	2015	106	50
Cheese ('000 tonnes)	2013	468	125
	2014	469	134
	2015	494	152
Cream ('000 tonnes)	2013	22	44
	2014	30	34
	2015	30	21
Milk powders (‘000 tonnes)	2013	67	88
	2014	66	125
	2015	61	146

Source: AHDB 2016, p.43

In response to concerns surrounding the long term impacts of this farmer exodus from the sector, which is often attributed to the effects of low farmgate prices for milk, a voluntary code of best practice for contractual relationships⁹ in the dairy industry was introduced ('The Code') in 2012, aimed at improving the economic viability of producers and rebalancing power within the dairy supply chain (DairyUK et al 2013) by ensuring that:

"Contracts between producers and purchasers must set out either a clear price, or a clear pricing mechanism (such as a formula) or a price notification process (the process by which the processor notifies the producer of the price), such that at any given point in time, a producer can be certain of the base milk price that will be paid for the milk produced." (ibid. p.2)

Following the introduction of the Code, it was believed that "in excess of 85-90% of milk volume in the UK" was covered by the Code (Newbery 2013, DairyCo 2013c).

An alternative interpretation of observed trends (outlined above) is that the increases in yield per cow and herd size at the farm level (and the resulting increases to national milk output, 2.2) could result in continued expansion in overall milk output, which has the potential to reduce the UK's current trade deficit for manufactured products and to improve its position with regards to dairy exports (assuming commensurate increases in processing capacity). Indeed, the strategy for the dairy sector proposed by DairyUK and others in 2014 is one of aggressive expansion in production capacity to "wipe out the trade deficit, by displacing imports and exporting where it makes business sense" (DairyUK et al 2014, p.7). This strategy was underpinned by the expectation of increased demand for meat and dairy products in developing nations, notably China (Garnett 2007, p.24).

⁹ <https://www.nfuonline.com/assets/6570>

The National Farmers Union (NFU) developed a similar vision of a more competitive UK dairy sector, based around improvements in efficiency of production and greater synergies throughout the supply chain, with one recommendation for farmers being to “increase output, through improving technical efficiency and expansion” (NFU 2013, p.7).

Such questions regarding the future competitiveness of the UK dairy sector on the global stage have come into sharper focus following recent political developments, including:

- The 2014 Russian embargo on imports of cheese following the imposition of trade sanctions in response to the annexation of Crimea¹⁰
- The abolition of EU quotas for milk in 2015, which was widely predicted to increase milk production within the EU with milk prices falling accordingly (IPTS 2009). Looking ahead, this increased competition may introduce a new challenge to the economic viability of UK milk production, and some studies suggest that UK milk production will decline (IPTS 2009; Drew Associates 2008).
- The UK’s decision to exit the EU, following the referendum of 2016, which may exacerbate the challenges facing UK producers, within a current climate of protectionism (Lang, Millstone and Marsden 2017).

2.3.2 Potential Social and Environmental Implications

The potential social and environmental implications of recent trends are often interconnected and will therefore be considered alongside one another.

At one extreme, some commentators suggest that the trends outlined above (2.2) represent a homogenisation of production approaches, converging on a ‘megadairy’ model of production (Lundgren 2011). Further, they express concerns regarding:

- The environmental impacts of such models, resulting from importing huge quantities of concentrated feed from off farm. Such feeds are often derived from soy or palm grown in the tropics, resulting in biodiversity loss and greenhouse gas (GHG) emissions due to forest and savannah conversion (Defra 2012, p.36), or are derived from crops that might otherwise have been used to feed humans (Garnett 2007)
- The standards of animal welfare associated with increasingly intensive farming practices (Jackson 2013; Soil Association / WSPA 2011; CIWF / WSPA 2010)
- The use of antibiotics within intensive production systems, with the associated threat of antimicrobial resistance (Jackson 2013)
- The local environmental impacts that may be associated with more intensive production approaches (as seen, for example, in the Environment Agency’s refusal in

¹⁰ <https://www.economist.com/news/europe/21696571-land-where-european-cheese-banned-one-mandares-make-his-own-war-and-cheese>

2010 of an application for a proposed 8,100 cow mega-dairy in Nocton, Lincolnshire; House of Commons 2011, p.36)

- The future viability of small family farms, and the broader impact on rural communities and the rural economy, in the face of the emergence of increasingly largescale, more intensive systems of production (Villarreal Herrera 2017, p.5).

By contrast, however, others argue that “... milk can be produced efficiently from any of the major systems that are currently practised in Britain ... Moreover, efficient milk production is possible at almost any scale of production” (DairyCo 2012a, p.4). This contrasting vision of the future is, therefore, associated with quite different environmental impacts.

Further, there is a risk that the complexity of such issues may be lost within mainstream debates, which may threaten to simplify arguments along lines such as ‘small is [inevitably] beautiful’ or ‘big is [inevitably] bad’ (Schumacher 1974). In practice, the above issues are all strongly contested.

This is demonstrated by considering just a single aspect of the potential environmental implications of increasingly intensive farming models, namely, GHG emissions including CO₂ and CH₄. On the one hand it has been claimed that emissions associated with more intensive farms may be *lower* per litre of milk produced, because an intensive farm may produce the same volume of milk as an extensive farm, albeit from fewer cows (therefore producing less methane per litre of milk; Garnett 2007; Foster et al 2007). A counter argument suggests that the methane emissions for each high-output cow are, nevertheless, *higher* than for each low-output cow, due to their higher-protein diets, and the larger volumes of food they consume. Moreover, high-output cows have a shorter productive lifespan, meaning that intensive farms experience a higher turnover of livestock and, consequently, a more frequent need for heifers (i.e. methane-producing, non-milk-producing cows) to replace these shorter-lived animals (ibid.).

The potential environmental implications of the trends already observed are made more uncertain by the current instability surrounding the future of environmental regulation of agriculture in the UK. In the UK, minimum environmental standards for dairy farming have been promoted through the Single Payment Scheme (SPS), introduced in 2003 under the Common Agricultural Policy (CAP), with farmers qualifying for subsidy under the SPS for adherence with “statutory management requirements” (SMRs) and standards of “good agricultural and environmental conditions” (GAECs); known as “cross compliance”. SPS was replaced in 2015 under the CAP reforms by a new Direct Payments Scheme, which, while broadly preserving the cross compliance requirements, made 30% of the subsidy dependent on farms adhering to “greening requirements”, which went beyond cross compliance requirements

by introducing requirements for crop diversification, and the preservation of areas of permanent grassland and “ecological focus areas” (Defra 2013, p.9-10). However, the UK’s decision to exit the EU, following the 2016 referendum has resulted in considerable uncertainty regarding the future regulation of food and agriculture in the UK.

Finally, recent UK food policy has been legitimated by the concept of “sustainable intensification”, or “simultaneously raising yields, increasing the efficiency with which inputs are used and reducing the negative environmental effects of food production” (Foresight 2011, p.35). Although improving the efficiency of milk production *can* coincide with meeting environmental sustainability objectives (Defra 2012, p.15), increased intensity of production is often at odds with environmental sustainability, meaning that satisfying “the need to produce more from less” is not straightforward (House of Commons 2012, p.29). For example, although larger herds may be more profitable and efficient this may come at a cost to biodiversity (Dewick and Foster 2007, p.25-26). The requirement for, and meaning and adequacy of, “sustainable intensification” within farming practice (Foresight 2011; NFU 2013) therefore remains a source of some dispute.

2.4 Summary

As outlined already, the purpose of this chapter is not to offer a position as to the validity of any of the above arguments, but to demonstrate that the economic, social and environmental outcomes associated with different production approaches are contested and expected to differ. This emphasises the importance of understanding the directions in which dairy farming is currently moving, which is the area of knowledge that this study aims to contribute to. An understanding of the directions that development will take, and the influence of buyer power upon such development, may provide an important contribution towards the current policy debate.

Chapter 3: Literature Review

This chapter considers a range of theoretical perspectives applied within studies of innovation and technological change in a range of sectors, including agriculture (3.1 – 3.4). It also considers some theoretical approaches to power and in particular its role within value chains for agricultural products (3.4 – 3.5). The purpose of this review is to establish a theoretical foundation on which to construct a framework for analysing the influence of buyer power upon patterns of technological change within UK dairy farms (which will be outlined in **Chapter 4**), and to further refine the research question that this study is aimed at answering (3.7).

3.1 Induced Innovation

The theory of induced innovation has provided a popular explanation for the generation of new agricultural technologies. In brief, induced innovation theory holds that:

“a change in the relative prices of factors of production is itself a spur to innovation and to inventions of a particular kind – directed at economising the use of a factor that has become relatively expensive” (Hicks 1932, pp.124-5).

Technological change is therefore induced by changes to factor input prices so that if, for example, the price of labour increases then activity will be directed towards the development of labour-saving technologies.

One of the most influential formulations of the induced innovation hypothesis was developed by Hayami and Ruttan (Hayami and Ruttan 1971) who suggested that, throughout the history of agricultural development, mechanical technologies have, broadly, served as a substitute for labour, whilst biological and chemical technologies have served as a substitute for land. They famously illustrated this through a comparison of the agricultural histories of the United States (which, they suggest, was characterised by the substitution of machinery for labour) and Japan (which was characterised by the substitution of chemical and biological inputs for land; Olmstead and Rhode 1993, p.102).

Further, Hayami and Ruttan suggested that changes in technology are induced not only by “conditions of factor supply” but also by “product demand” (Olmstead and Rhode 1993, p.101) as well as “as a result of exogenous advances in the state of science and technology” (Hogg 2000 p.50). Similar perspectives have focused more heavily on the role of market demand in

inducing technological change, holding, for example, that “the rate of technological innovation of a given commodity in a market economy is responsive to the market demand for that commodity in the economy” (Lin 1992, p.14).

The potential relevance of such approaches to the current study is clear: the debate surrounding the recent and future direction of the UK dairy farming sector is centred on the question of whether (and how) farmers’ technological approaches are influenced by market signals (such as, for example, farmgate prices for milk, paid by powerful buyers). However, some critiques of induced innovation theory suggest that it may not offer the most useful theoretical basis in which to ground this study.

3.1.1 Critiques of Induced Innovation

The theory of induced innovation has attracted criticism regarding its treatment of the *process* and *sources* of technological change. These (related) critiques can be summarised as follows:

- Induced innovation places the *process* of innovation inside a “black box” (Ruttan 1997, p.1521). Put differently, new technologies may appear as “manna from heaven” (Freeman 1994; Scherer 1999, p.53): factor prices are regarded as the drivers of innovative activity, but the capacities to act upon such drivers are entirely taken for granted. In reality, however, technologies may not be available ‘on demand’, ready and waiting to be deployed as the necessary conditions arise. Instead, some underlying process of ongoing innovative activity (e.g. research and development) must be taking place, which leads to the question of *how* this activity is directed and sustained.
- A further consequence of the ‘black-boxing’ of the innovation process is a potential disregard for *where* innovative activity is located and *by whom* it is performed. If new technologies appear “like manna from heaven” then there is a risk that the *sources* of such innovation may also be taken for granted. Given that this study is interested in determining whether (and how) buyer power influences technological change, it may be important to identify and characterise sources of that change including, for example, whether technologies are generated on the farm or whether they are developed by third parties, or whether they are developed as a result of collaboration between groups of farmers, and between farmers and third parties (such as extension agencies or, potentially, buyers). Pavitt, for example, famously described mature sectors, such as agricultural production, as “supplier-dominated” sectors, by contrast with newer sectors (Pavitt 1984). By this, he meant that agricultural producers do not typically generate innovations themselves but instead adopt the innovations generated by input “suppliers” (which may be private firms, research bodies or public agricultural

extension services). In the context of this study a theoretical perspective is required that understands technological change as incorporating:

- (a) The adoption and application of technologies (including both technological artefacts and processes) that have been developed by external suppliers or consultants. In the case of dairy farming this includes third parties that produce:
 - ‘Hardware’ – e.g. agricultural inputs such as feed, genetic resources, veterinary medicines, milking machines, etc, or
 - ‘Software’ – e.g. knowledge/skills inputs such as guidelines or best practice regarding animal husbandry or grassland management.
- (b) The development of new technologies (both technological artefacts and processes) by farmers themselves (which may include, for example, entirely new technologies or novel / context-specific approaches to implementing or adapting existing technologies that have been developed by third parties).
- (c) Farmer-farmer and farmer-third party interaction and/or knowledge exchange.

3.2 Studies of the Diffusion of Agricultural Innovations

Another popular approach to understanding technological change in agriculture involves the study of the diffusion of innovations (Griliches 1957; Feder and Umali 1993). Diffusion is “the process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers 1983, p.34). The popularity of this theoretical approach, with regards to the study of technological change in agriculture, may be related to the above observation that agriculture is a “supplier-dominated” sector (i.e. that farmers are typically “users” of technologies developed by other actors; Diederer et al 2003). Such studies have aimed to account for the successful / unsuccessful uptake by farmers of particular technological artefacts or approaches, such as conservation agriculture (Knowler and Bradshaw 2007), organic agriculture (Burton et al 2003), and artificial insemination (Howley et al 2012), or of ‘innovation’ more generally (Diederer et al 2003).

However, the objectives of diffusion studies are often quite different from those of this study, meaning that there may be some potential challenges to applying a diffusion perspective. For example, “population” models of diffusion typically seek to understand how, when and why a technological innovation achieves widespread adoption (or not) amongst a population of users, often attributing diffusion to “an endogenous process of information propagation” (Diederer et al 2003 p.330). Within such studies analysis may centre upon rates of technological innovation and adoption, and on the categorisation of users as, variously, “innovators”, “early adopters”,

the “late majority” and “laggards”, depending upon the timing of their adoption (Rogers 1983, p.22). By contrast, this study is more concerned with identifying how and why different users select between different (*not necessarily specified*) technological approaches (involving *multiple* technologies). The relevant unit of analysis for the present study is therefore the farm and/or sector rather than the artefact, and the focus is upon the mechanisms underlying (rather than rates of) technological change.

By contrast, other diffusion studies – categorised broadly as “decision theoretic models of innovation” – seek to account for the contribution of a range of distinguishing variables towards farmers’ decision making, with farmers assumed to exhibit profit maximising behaviour (Diederer et al 2003 p.330). Such variables may include farm size, location, farmer education, or age (Sunding and Zilberman 2001, p.231-4), the role of availability of labour, equity, and attitude to risk (Abadi Ghadim and Pannell 1999), the amount of technology used in the production process, the opportunities for product differentiation within the sector, the degree and type of regulation (Diederer et al 2003, p.332), or farmers’ motivations, values, objectives and behavioural influences (Howley et al 2012, p.172). The aims of such studies are closer to those of this study.

Some valuable conceptual insights have emerged from the diffusion literature, which may be of relevance to the needs of this study, namely that the speed of diffusion of a technological innovation may depend whether it is perceived as having “greater relative advantage, compatibility, trialability, observability, and less complexity” relative to alternatives (Rogers 1983, p.16). Of particular relevance are:

- **Compatibility**, or “the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters” (ibid. p.15). Indeed, Feder and Umali observe the importance of compatibility with adopters’ needs, suggesting that: “Most agricultural technologies introduced in the last three decades, and the high-yielding varieties (HYVs) in particular, are in fact a package of interrelated technologies (for example, fertilizer, herbicides, and chemicals). Accordingly, one major focus in the literature in recent years has been the investigation of the decision-making process characterising choice of the optimal combinations of the components of a technological package over time” (Feder and Umali 1993 p.216). Moreover, Diederer et al suggested that “many innovations... do require adjustments to local circumstances and adaptations to specific uses” (Diederer et al 2003, p.329), while Wilson stresses “the importance of *compatibility* of technological innovations with existing values, past experiences and needs” (Wilson 2007, p.56).
- **Complexity**, or “the degree to which an innovation is perceived as difficult to

understand and use" (Rogers 1983, p.15); and

- **Trialability**, or "the degree to which an innovation may be experimented with on a limited basis ... Ryan and Gross (1943) found that every one of their Iowa farmer respondents adopted hybrid-seed corn by first trying it on a partial basis" (ibid.).

Finally, diffusion studies have also sought to model "bandwagon effects" in which "the sheer number of organisations adopting an innovation can cause a bandwagon pressure, prompting other organisations to adopt this innovation" (Abrahamson and Rosenkopf 1993, p.487). Such effects may be of interest to this study, given the concerns expressed within mainstream discussions regarding the 'homogenisation' or convergence of farming approaches upon more intensive modes of production (see above, **Chapters 1 and 2**).

3.3 Evolutionary Perspectives: A Coupled Model

Evolutionary theories of innovation were developed partly in response to the shortcomings associated with 'linear' models of technological change (Brooks et al 2009); both "demand-pull" perspectives and "science-push" perspectives (Dosi 1982).

Drawing on the work of Chris Freeman and Keith Pavitt, the evolutionary perspective is focused on the ongoing processes of "search" and "selection" within firms, based in turn around firms' "routines" (Ruttan 1997, p.1522). It aims to provide "a more realistic description of the internal working of the black box" (ibid.), in which technological change is regarded as an ongoing and dynamic process.

Rejecting the assumptions underpinning neoclassical economic theories – including the assumptions of perfect information and rational actors – evolutionary theorists prefer to depict "boundedly rational" actors who engage in "satisficing" behaviours (Leiponen and Drejer 2007 p.1222; Ruttan 1997, p.1522). The attraction of this approach, from the perspective of the current study, is that it explicitly assumes (and aims to explain) a degree of variability in the abilities of different actors to respond to input changes. This perspective may therefore provide a platform from which to interpret structural changes in the dairy sector that appear to arise from (and result in) a non-uniform response by farmers to market developments (i.e. in which some farmers drop out of the market, while others change their production approaches, while others adhere to their established production approaches).

From an evolutionary perspective, the relationships between generators and adopters of technologies may be significant. Hence, there is a need to identify and characterise the sources of technological change (as outlined above, 3.1.1). Although they are often regarded as discrete processes, an evolutionary perspective argues that there are interactions between the *generation* and the *adoption* of technologies. This is typically described as a “coupled” process in which the generation of new technologies results from ongoing interactions between “technology-push” and “demand-pull” (Dosi 1982). Therefore, within a coupled model, factor input price change cannot be the sole determinant of innovative activity. In a coupled view, adoption decisions are necessarily constrained by the available range of technologies, which itself is dependent upon the extent of current scientific and technical knowledge. At the same time, however, the search for new scientific knowledge may be directed to some extent by the demands of the market (either real or perceived). The relative power of market participants is therefore a factor that can be readily incorporated into an evolutionary perspective, which is once again attractive given the aims of this project.

As adopters of technologies, agricultural producers may represent ‘demand-pull’ in this context, whilst ‘technology-push’ may be represented by the available range of technologies produced by technology suppliers. Further, the influence that producers are able to exert upon the generation of technology may depend to some extent upon the relative power of producers versus suppliers, and the mix of public sector versus private sector suppliers (Sunding and Zilberman 2001).

3.3.1 Technological Regimes, Paradigms and Trajectories

One of the most commonly-cited articulations of technological change as a coupled process was developed by Giovanni Dosi (von Tunzelmann et al 2008). Dosi’s view of technological change was centred on the notions of the “technological paradigm” (a concept similar to Nelson and Winter’s “technological regime”¹¹; Nelson and Winter 1982) and the “technological trajectory”.

A *technological paradigm*, Dosi suggested, is analogous to Kuhn’s conception of a scientific paradigm (Dosi 1982), namely, it is “an ‘outlook’, a set of procedures, a definition of the ‘relevant’ problems and of the specific knowledge related to their solution” (ibid, p.148). Moreover, Dosi suggested that “economic and institutional factors” play a role in the “selection and establishment” of technological paradigms, which, having been established, develop through “the interplay between endogenous economic mechanisms and technological innovations” (ibid.).

¹¹ NB: This study regards the terms ‘technological paradigm’ and ‘technological regime’ as, essentially, interchangeable and will, for the sake of consistency, use the latter (unless directly quoting an source).

A technological paradigm therefore serves to define both the ‘relevant’ problems that technological progress is aimed at solving (which might be thought of as the ‘goals’ of technological progress, see below 3.3.6), and the practical approaches to solving those problems.

It is important to note that, as a coupled model of technological change, this perspective does not deny the role of movements in factor input prices. Instead, it holds that such “inducement mechanisms ... are likely to be fundamental [factors] influencing both the rate and direction of technological progress, but *within the boundaries* defined by the nature of technological paradigms” (Dosi 1988, p.226-7).

For Dosi, a *technological trajectory* is “the direction of advance within a technological paradigm” (Dosi 1982, p.148) or “the pattern of ‘normal’ problem solving activity (i.e. of ‘progress’) on the ground of a technological paradigm” (ibid. p.152).

3.3.2 Levels of Analysis

The Dosian perspective is not without its critics. One objection is that it is unclear whether the concept of a technological regime is intended to be applied at the firm-level or sector-level of analysis (Teece 2008, p.510).¹²

This relates in turn to a broader question of whether evolutionary approaches have focused too frequently upon the analysis of sector-level trends at the expense of explaining sub-sector-level heterogeneity. For example, Leiponen and Drejer suggest that, paradoxically, “in addition to the view of firms as boundedly rational local searchers, the evolutionary economic theory of industrial dynamics also has generated the notion of technological regimes [paradigms] that are assumed to apply at the level of industries” (Leiponen and Drejer 2007, p.1222).

They contrast the approach of evolutionary scholars (what they refer to as the “regime literature”) against that of scholars writing within the strategic management tradition, suggesting that the former have generally studied innovation behaviours at the level of industries, focusing on differences in approaches to and patterns of innovation between different sectors of the economy (which “portrays firm behaviour as largely industry specific”,

¹² For example, Malerba and Orsenigo’s definition of “technological regimes” is strikingly similar to Dosi’s “technological paradigms”: “The technological environment defines the nature of the problems that firms have to solve in their innovative activities, the incentives and constraints to particular behaviours and the basic dynamics [sic] mechanisms of evolution of firms, technologies and industries... the technological environment at a given time is ... the *technological regime*” (Malerba and Orsenigo 1993, p.46). However, despite this broadly similar definition, their attention appears to centre largely on *sectors* as the relevant unit of analysis.

ibid. p.1223). By contrast, the strategic management literature “specifically focuses on the differences across firms and their implications for firm performance” (ibid.).

Through an empirical study of Community Innovation Survey (CIS) datasets for Denmark and Finland, Leiponen and Drejer found evidence of considerable *intra-industry* heterogeneity in firms’ innovative activities, with “only about half of the observed industries [having] a dominant innovation regime¹³, defined as 50% or more of the firms in an industry being affiliated with the same regime” (ibid. p.1224). Their findings suggest that “regimes are not industry-level constructs but operate at the level of industry subgroups or even individual firms” (ibid. p.1233).

A related criticism levelled against the Dosian approach is that the concept of a ‘trajectory’ (i.e. singular) as the direction of advance within a paradigm introduces the potential for a deterministic conception of technological progress, which may overlook the range of possible approaches towards solving a particular problem from a particular starting point, and the contribution of a range of factors towards that diversity of approaches. For example, MacKenzie and Wajcman have argued that:

“If we find technologists operating within a paradigm – taking one technical achievement and modelling future work on that achievement – it becomes tempting to treat this as somehow self-explaining and discuss it in terms of mechanical analogies such as following a technical ‘trajectory’. But to do this would be to miss perhaps the most fundamental point of Kuhn’s concept of paradigm: the paradigm is not a rule that can be followed mechanically, but a resource to be used. There will always be more than one way of using a resource, of developing the paradigm. Indeed groups of technologists in different circumstances often develop the same paradigm differently ... much can be hidden by considering the further development of a paradigm as simply a ‘technological trajectory’.” (MacKenzie and Wajcman 1999, p.14)

Again, this objection appears to centre on the level of analysis at which the concepts of ‘regime’ and ‘trajectory’ can be (and are in practice) applied.

How damaging are these critiques to the Dosian approach? Do they undermine the value of technological regimes and trajectories as analytical tools?

Certainly, although Dosi describes technological trajectories as “*the pattern of ‘normal’ problem solving activity*” (Dosi 1982 p.152, authors italics) or “*the direction of advance within a technological paradigm*” (ibid p.148, authors italics), it is clear that there is rarely a *single*

¹³ NB: Leiponen and Drejer appear to use the terms “innovation regime” and “technological regime” interchangeably, viewing the “regime” as “a useful concept to characterise firms’ industrial operating environment” (Leiponen and Drejer 2007, p.1221)

solution to any given technological problem, and definitely not one that can be known in advance. Indeed, Dosi himself states that the paradigm defines “notional *opportunities* of future technical advance” (Dosi 1997, p.1534, author’s italics), and it seems obvious that he envisaged a trajectory not as a single solution but as incorporating a “cluster” of overlapping approaches.

For example, he argued that progress within a paradigm is based on “technological and economic trade-offs” specific to the paradigm (Dosi 1982, p.148):

“A technological trajectory ... can be represented by the movement of multi-dimensional trade-offs among the technological variables which the paradigm defines as relevant. Progress can be defined as the improvement of these trade-offs. One could thus imagine the trajectory as a ‘cylinder’¹⁴ in the multidimensional space defined by these technological and economic variables. (Thus, a technological trajectory is a cluster of possible technological directions whose outer boundaries are defined by the nature of the paradigm itself).”
(Dosi 1982, p.154)

It is reasonable to assume that the same set of economic and technological variables may be traded-off against each other in numerous possible ways, meaning that the trajectory of development may – at a more granular level of analysis – incorporate many possible configurations of these trade-offs at the sub-sector level, which would differ according to the relative ‘weight’ that firms accord to different economic and technological factors.

If the above criticisms do not undermine the utility of Dosi’s conceptual approach, then they do at least highlight that care must be taken when deploying such analytical tools. Indeed, von Tunzelmann et al observed that “it might be dangerous to consider technological paradigms as prescriptive, as many firms are innovative precisely because they are able to move out of the paradigms they are currently in ... [which] highlights the complex way in which technological

¹⁴ NB: This notion of the trajectory as a ‘cylinder’ itself raises some challenges. The first of these involves the difficulty of visualising a “multi-dimensional space”, let alone what a three-dimensional shape (a cylinder) would look like within that space. The second (related) question concerns the issues of time and dynamics. Presumably the perimeter of the cylinder in cross-section represents the ‘outer boundaries’ of the trajectory, which are determined by the paradigm, whereas the height of the cylinder represents the dimension of time. In other words, the cylinder is a dynamic representation of a trajectory. Indeed, one might further imagine the radius of the cylinder increasing or decreasing over time, due to changes in trade-offs between technological and economic variables selected by the paradigm, so that the cylinder might appear as a series of ‘funnels’ connected to one another. However, if trajectories are being represented dynamically, this raises the question of why the paradigm itself is not also being represented dynamically, and along the same timescale, but is instead defined as a (presumably temporally static) “multidimensional space”. The notion of a paradigm as a static entity, with the trajectory being the dynamic representation or expression of that paradigm seems inconsistent with Dosi’s earlier definition of paradigms and trajectories, and indeed the entire philosophical approach underlying evolutionary theory. Instead, it seems sensible (and more consistent with Dosi’s own definition of the terms) to modify or rework Dosi’s visual description, depicting *the paradigm* as a cylinder (or, more specifically, a prism) within which multiple trajectories operate (as smaller overlapping and interacting prisms).

paradigms *guide, but do not determine*,¹⁵ choices” (von Tunzelmann et al 2008, p.480; author’s italics).

Moreover, it is suggested that the analyst must take care to be explicit about the analytical level(s) at which these tools are being deployed. Smith et al argued that the regime concept can – and should – be applied at various levels of analysis (from artefact, to firm, to sector etc), provided that the analyst takes care to be explicit and consistent in this application:

“The term ‘regime’ is used as a short-hand for a series of complex, nested real world phenomena ... Regimes exist across different empirical scales... [for example] At a relatively high level of aggregation, the electricity-generating regime is dominated by rules and practices relating to centralised, large-scale (usually thermal) power technology and high voltage alternating current grid infrastructures ... At the lower level of aggregation of individual power technologies, the electricity generating regime as a whole spans a variety of nested subordinate regimes, such as that based on the coal-fired steam turbine, the nuclear fuel cycle, large-scale hydro-electricity or gas-fired combined cycle turbine systems ... Clearly, there is a need carefully to distinguish in any given context between what constitutes the ‘nested’ and the ‘spanning’ regime, and to be precise in the empirical application of the concept.” (Smith et al 2005, p.1493)

Indeed, the technological regime is, broadly, the way in which a particular problem (or societal function) is defined and the approach taken to its solution. Such problems / functions can be general and far-reaching (i.e. cross-sector) – e.g. the disposal of waste or the generation and distribution of power – or more specific and localised (e.g. at the individual firm or even the user level).

In spite of the potential ambiguities outlined above, the evolutionary perspective – and the concepts of regimes and trajectories – may provide a useful theoretical context within which to situate this study, because:

- It avoids the potential oversimplifications associated with linear accounts of change, viewing change instead as progress towards goals that are defined (and constantly redefined) by the interactions between a range of interrelated factors
- It understands that future technological change is therefore contingent upon current and past changes (and that it may therefore differ from firm-to-firm)
- It permits the topic to be approached at multiple analytical levels in order to more effectively analyse the above.

¹⁵ NB: It is notable that Dosi himself often uses the term “determines” (e.g. Dosi 1982, p.152; Dosi 1997 p.1534: “(each ‘paradigm’) determines the notional opportunities of future technical advance”)

Compared with neoclassical perspectives, such as induced innovation theory, evolutionary perspectives may therefore provide a more useful theoretical outlook from which to approach the analysis of patterns of technological change within the UK dairy sector.

However, although evolutionary theory encourages us to view technological development not as the product of *either* 'science-push' or 'market-pull', but rather as the product of *both* these *and other* (e.g. social, economic, technological or structural) factors, there remains a need to determine the respective relative contributions made by these various factors towards technological change, in order to enrich the analytical potential of the theory itself, as well as the quality and value of policy advice derived from its application. As a 'circular' model of technological change, an evolutionary perspective may present the analyst with the dilemma of (a) identifying a 'starting point' for the analysis, and (b) determining the respective relative contributions towards technological change made by the various interacting components of the model. In other words, the application of an evolutionary model to real world problems may be limited by the extent to which it is able "to differentiate more from less important links and interdependencies" (Millstone 2010, p.294).

3.3.3 Technological Change: Continuity and Discontinuity

There are at least two related and recurring themes that intersect the evolutionary perspectives outlined above, which may be of particular relevance to the interests of the present study.

The first is that "history matters" (Freeman and Soete 1997, p.240). Where firms (or farms) can go may be conditioned to some extent by where they have already been: "what a firm can do depends heavily on its past history of development of competences and on how they are organised" (Malerba and Orsenigo 1993, p.46), and technological learning in firms is cumulative in nature (Bell and Pavitt 1993, p.168), meaning that "technological search and choice in firms are therefore constrained by what they... have already learned, and their technological activities tend to follow a 'trajectory'" (Pavitt 1987, p.186).

Technological change is therefore not a straightforward, frictionless response to a single external stimulus (such as a change in market prices or an advance in scientific knowledge). Instead it may be limited, shaped or guided by prevailing bodies of knowledge and accepted modes of problem-solving. Such bodies of knowledge may themselves be embedded within technological artefacts currently in use, as well as in the individuals and firms that use and develop those artefacts. Put differently, bodies of knowledge that inform technological search and selection may be either "codified" or "tacit" (Polanyi 1967; Cowan et al 2000). This in turn

implies that it may be useful to adopt an analytic approach that can operate at different levels of aggregation, from the level of artefacts, to groups of individuals, to firms, sectors and so forth.

Having said that, the second theme is that the bodies of knowledge – both tacit and codified – and modes of thinking that serve to highlight relevant societal problems (as well as approaches to their solution) are dynamic and evolving and, crucially, *are open to influence by technological and economic factors* (Dosi 1982). In other words (and of particular relevance to the interests of this study) buyers – and especially powerful buyers – may have some ‘say’ in how technological regimes are established and how they subsequently evolve.

Although at first glance the above statements may appear potentially contradictory they can be thought of as parallel strands of work, which view technological change as being characterised by periods of *continuous* (i.e. incremental) change, punctuated by periods of *discontinuous* (i.e. radical) change (Dosi 1982, p.147); albeit these perspectives may differ in the extent to which they emphasise the role of human agency within that process (MacKenzie and Wajcman 1999; see further below). The value of these different perspectives, for the purposes of this study, is that they may offer a theoretical basis for identifying different degrees of change (e.g. incremental or radical), and for considering the contribution of selected factors towards these (thereby providing a means of engaging with and critically examining the question of whether structural changes in dairy farming are the result of long run technological advances or whether they are directed by human agents, such as powerful buyers (see above, **Chapter 1**).

The following sections explore how these related streams of thought have been developed by individuals working within the evolutionary tradition. This involves a consideration of the mechanisms through which development is stabilised and destabilised and begins with a discussion of the concept of ‘path dependence’ as a feature of ‘technological’ or ‘socio-technical systems’ (**Sections 3.3.4 to 3.3.8**), before moving on to discuss agency and social factors (**Section 3.4**).

3.3.4 Path Dependence

“History matters” in the sense that *all* development is “past dependent” (Araujo and Harrison 2000, p.3). *Path* dependence, however, implies something more than this, and “if ‘history matters’, both actors and analysts have to be clear in how it matters and through what mechanisms history is being carried forward” (ibid. p.12).

The notion of path dependence has received considerable attention from scholars working within a broad range of disciplines (Dobusch and Schußler 2012). For those interested in the

history of technology, however, the works of Brian Arthur and Paul David provide a reference point.

In his classic paper, "*Clio and the Economics of QWERTY*" (David 1985), David asserted that "... a *path-dependent* sequence of economic changes is one of [sic] which important influences upon the eventual outcome can be exerted by temporally remote events, including happenings dominated by chance elements rather than systematic forces" (David 1985, p.332). Historical events or accidents may therefore have a critical impact on the development or adoption of technologies.

The paper examined the emergence and prevalence of the standard 'QWERTY' keyboard layout in spite of the presence of apparently superior alternatives. David described the typewriter as one component of a larger, "technically interrelated" system of production (ibid. p.334). This led him to identify the interaction between the components of this system – notably "hardware" (i.e. typewriter) and "software" (i.e. human operator) – as a source of path dependence. In particular, he highlighted three features that contributed towards the lock-in to QWERTY as an industry standard, which stem from the fact that 'touch' typing was "from its inception adapted to the ... QWERTY keyboard" (ibid.). These features are:

- **Technical interrelatedness** – i.e. "the need for system compatibility between keyboard 'hardware' and the 'software' represented by the touch typist's memory of a particular arrangement of keys" (David 1985, p.334); reminiscent of the concept of 'compatibility' developed by diffusion scholars (3.2)
- **Economies of scale** – i.e. the process by which "the overall user costs of a typewriting system based upon QWERTY (or any specific keyboard) ... tend to decrease as it gained in acceptance relative to other systems." (ibid., p.335)
- **Quasi-irreversibility of investment** – i.e. there are "high costs of software 'conversion'" (ibid., p.336), meaning that, once typists are familiar with the QWERTY layout, the expense associated with retraining them hinders potential moves to alternative keyboard layouts.

Although David was studying a sector-level phenomenon, such processes may operate equally at the firm (or 'local') level (Dobusch and Schußler 2012).

3.3.5 Positive Feedbacks

Other scholars have identified similar features of path dependent processes. Although the terminology used within the literature varies, there is often a clear congruence or overlap between the processes under discussion. For example, Arthur describes path dependence as a stochastic process, occurring under conditions of *increasing returns* to adoption (Arthur, 1989, p.116), conditions corresponding closely to David's 'economies of scale'.

Arthur observed that where two or more technologies are in competition within a marketplace, and where increasing returns result from the adoption of those technologies (i.e. "the more they are adopted, the more experience is gained with them, and the more they are improved" and therefore adopted, *ibid.*), there will be multiple possible outcomes with regard to which technology 'wins'. Although the range of outcomes (i.e. paths) can be identified, it is not possible to predict which one will transpire in practice because chance events (rather than technical superiority) may give one or other technology an early 'lead', with the increasing returns to adoption providing the momentum for that technology to "corner the market" thereafter (*ibid.*). This characteristic is known as "non-ergodicity": "historical 'small events' are not averaged away and 'forgotten' by the dynamics – they may decide the outcome" (*ibid.* p.117)

Increasing returns is an example of a *positive feedback* or *self-reinforcing mechanism* (the two terms are often treated as interchangeable, and this study will use the former). Arthur proposes four sources of such mechanisms (Arthur 1994 p.112):

- **Large set-up or fixed costs** "which give the advantage of falling unit costs to increased output";
- **Learning effects** "which act to improve products or lower their costs as their prevalence increases"
- **Co-ordination effects** "which confer advantages to 'going along' with other economic agents taking similar action"; and
- **Adaptive expectations** "where increased prevalence enhances beliefs of further prevalence."

Building on the work of Arthur, some scholars have stressed the importance of distinguishing increasing returns as a specific subset of a broader set of positive feedbacks, rather than a strict prerequisite for path dependence, noting that increasing returns may only be "a temporary phenomenon resulting from positive feedback" (Dobusch and Schußler 2012, p.638) or a "phase" within path dependent processes (*ibid.* p.636). Indeed, "self-reinforcing mechanisms

may be accompanied by increasing returns, but also with constant or even decreasing returns – although this latter should not be confused with negative feedback” (ibid. p.637).

Dobusch and Schußler define path dependence as “a process triggered by contingent events, then moved along through positive feedback mechanisms until it results in rigidity or lock-in”. Therefore, they regard positive feedback as a “necessary condition” for path dependence (ibid. p.618). Following a wide-ranging review of the literature on path dependence, they identified a long list of what they describe as “‘typical’ positive feedback mechanisms”, which they summarised into the following categories (ibid. p.623):

- **Complementarity effects**, which they define somewhat broadly as “stemming from two or more otherwise independent social processes” (see further, below, 3.3.8 for a more in depth examination of complementarity effects);
- **Investment and learning effects**, “because of the accumulation of specialised, but non-transferable stocks of investment or knowledge”;
- **Co-ordination effects**, which captures “utility resulting from others following the same path”;
- **Expectation effects**, “similar to self-fulfilling prophecies”.

For the purposes of this study, identifying and analysing the sources and effects (or absence) of such mechanisms at farm level may highlight and illuminate instances of continuity and discontinuity in farms’ development. Note that complementarity effects and investment and learning effects correspond broadly to the notions of ‘compatibility’, ‘trialability’ and ‘complexity’ drawn from diffusion studies (see above 3.2), while co-ordination effects and expectation effects may correspond loosely to the notion of ‘bandwagon effects’ (ibid., p.625).

3.3.6 A Systems Perspective

Many of the positive feedbacks outlined above result from interactions between components operating within a *system*. The literature on “large technical systems” provides some interesting parallels to the path dependence literature discussed above, as well as some additional analytical tools.

A systems perspective may offer a useful conceptual basis from which to approach to the debate surrounding technological change in dairy farming, given that dairy farms may be readily understood as systems of interacting components (including livestock, feed, housing, breeding, healthcare, waste management technologies and more; see further **Chapter 5**), nested within a broader sector-level system (the value chain for liquid milk) and its associated socio-

technical regime. This perspective would suggest that a farmer's decision to adopt new technologies may be based upon how compatible those technologies are with the farm's current system of production – including the farmer's current body of knowledge, or capabilities – meaning that existing models of production may effectively serve to constrain future patterns of technology adoption, and that different farms may react differently to the same (or similar) stimuli. Notably, diffusion studies that have sought to model farmer decision-making with regard to technology adoption have identified the “current technology in use” as a key variable affecting farmers' adoption decisions (e.g. Diederer et al 2003, p.332), suggesting that “experience with innovations of similar types will most likely influence adoption in a positive sense” (Abadi Ghadim and Pannell 1999, p.152).

Moreover, from the point of view of understanding the effects of buyer power upon farms, it may be instructive to view farms as ‘open’ rather than ‘closed’ systems, meaning that they do not operate independently of their surrounding physical, economic and institutional environment (Hughes 1983, p.5): although many components are controlled by the farmer, others (e.g. geography and climate, or markets and regulations) may be either partially within – or completely outside of – the farmer's control. Farms' development may therefore be contingent upon their particular context.

Within the large technical systems tradition, Hughes' work on the electric power system provides an important benchmark.¹⁶ Hughes defines a system as being “constituted of related parts or components ... connected by a network or structure... [and] often centrally controlled”. He adds that, “because the components are related by the network of interconnections the state, or activity, of one component influences the state, or activity, of other components in the system” (Hughes 1983, p.5). The interconnected nature of system components gives rise to what Hughes terms “reverse salients”. A reverse salient “is an area where the growth of technology is seen as lagging ... Technologists focus inventive effort, like generals focus their forces, on the elimination of such reverse salients” (MacKenzie and Wajcman 1999, p.16). Put differently:

“A reverse salient appears in an expanding system when a component of the system does not march along harmoniously with other components. As the system evolves toward a goal, some components fall behind or out of line. As a result of the reverse salient, growth of the entire enterprise is hampered.” (Hughes 1983, p.79)

¹⁶ Notably, a large technical systems perspective has been used to examine the effects of market liberalisation upon the electricity system (Markhard and Truffer 2006). This may be of relevance to the current study, given that it is focused on understanding patterns of technological development following the abolition of the Milk Marketing Board (MMB); see **Chapter 2**.

In a clear analogue to the concept of path dependence, Hughes cites “momentum” as a persistent feature of systems, which consists of “mass, velocity and direction” (ibid. p.15):

- **Mass** corresponds closely to the investment and learning effects identified by path dependence theorists and includes “machines, devices, structures and other physical artefacts in which considerable capital has been invested”, as well as “the involvement of persons whose professional skills are particularly applicable to the system” (Hughes 1983 p.15; i.e. David’s “hardware” and “software”). Although path dependence scholars also describe the interaction between technological and human components (with David, for example, regarding it as a source of technical interrelatedness), a systems perspective is arguably more explicit about the pervasive quality of such interactions. Indeed, Hughes views the electrical system as a “*socio-technical system*” (Hughes 1983 p.140, p.465, author’s italics, see 3.3.7).
- **Velocity** is the rate at which the system grows (i.e. how rapidly its mass increases; Hughes 1983). Relating this once again to the path dependence literature, it can be seen that positive feedbacks will increase system velocity and, in turn, momentum. Such positive feedbacks may result from the “complementary interaction of system components, [which] generates ‘positive externalities’, strong growth and systems acquiring momentum” (Markhard and Hoffman 2016, p.64).
- Hughes associates **direction** with the “goals”¹⁷ of a system and suggests that, in more established systems, the determination of goals becomes less important as “momentum provides an inertia of directed motion” (Hughes 1983 p.15). There is a clear congruence between Hughes’ systems approach and the Dosian approach outlined above: the solution of “‘relevant’ problems” (Dosi 1982, p.148) outlined by a technological paradigm / regime can be thought of as being equivalent to the goals towards which technological change is directed and towards which it progresses. Changes to goals would therefore be associated with changes in technological regimes and trajectories. Moreover, for Hughes, reverse salients serve to highlight ‘critical problems’, and engineers and inventors seek to “maintain ... momentum by solving the critical problems that frustrated growth of the system” (Hughes 1983, p.79).

The issue of direction provides a potentially significant distinction between a socio-technical systems perspective and the path dependence perspectives described already. Although Arthur defines technology in broad terms as “[methods] to carry through any given economic purpose” (Arthur 1994, p.15), the question of how, when and by whom

¹⁷ Indeed, as MacKenzie and Wajcmann point out “The very concept of ‘reverse salient’ makes sense only if a technological system is seen as oriented to a *goal*.” (MacKenzie and Wajcmann 1999, p.18).

such purpose is determined is not a central concern to him. By extension, the path dependence literature is not particularly focused on the question of *why* a particular path is selected (e.g. who chooses it and for what reason). Instead, the main emphasis is on understanding the processes by which a path, having been established, is stabilised over time. Indeed, the path dependence literature has been criticised by some for being deterministic and for sidelining the role that human agents may play in determining the direction of technological development (Garud et al 2010; Sutherland et al 2012).

However, by specifying *direction* as a key element of technological momentum, and by viewing direction as being related to system goals, Hughes presents a conceptual outlook that is concerned with understanding, describing and accounting for the persistence of technological trajectories, as well as their genesis and their potential for change under the action of agency. This is useful given that the current study is interested in how trajectories are established, maintained and changed, and in the contribution of both human and technological components towards this.

3.3.7 Socio-technical Systems and Regimes

While there is broad agreement that socio-technical systems such as those described by Hughes are composed of a multitude of interacting human, technological and other components, there is an array of different potential definitions of their scope, form and content, and diverse approaches to their analysis.

Notably, transitions theorists – such as Frank Geels – have made extensive use of the concept of socio-technical systems. Geels’ definition of socio-technical systems begins at the broad, abstract level as “the linkages between elements necessary to fulfil societal functions” (Geels 2004a, p.900). His exposition of these “necessary elements” is detailed and wide-ranging. First, he distinguishes the production, diffusion and use of technology as separate “sub-functions” of socio-technical systems, which are fulfilled using various “resources”. He suggests that the basic elements and resources of a socio-technical system include (ibid.):

- The transfer of knowledge (education)
- Scientific knowledge
- Labour / human resources
- Technological design / knowledge
- Capital (money)
- Tools / machines
- Natural resources / parts
- Regulation which produces “trust” (quality, norms, property rights, laws)

- Facilities for repair / maintenance
- Cultural meaning
- Complementary artefacts (possibly linked into a technical system).

Drawing upon (and expanding) the notion of technological regimes, Geels uses the concept of the “socio-technical regime” to encapsulate the various institutions, rules and norms according to which socio-technical systems function and are governed, which contribute to the stability of systems (Geels and Kemp 2007, p.443). These regimes “sustain existing trajectories of development” (Smith 2007, p.428). Geels suggests that the elements and linkages that comprise socio-technical systems are “the result of activities of social groups which (re)produce them” (Geels 2004b, p.33), which may include producers of technology, users, policymakers and so forth. Socio-technical regimes represent the different regulative, normative and cognitive rule-sets that co-ordinate these activities (Geels 2004b, p.33; Genus and Coles 2008 p.1438); or the “deep structure” underpinning a socio-technical system (Genus and Coles 2008, p.1438).

In this view, systems and regimes “co-structure each other” (Geels and Kemp 2007, p.442) and rules (such as norms, rights and laws) are not only a component of a socio-technical system, but also provide a medium through which all system components (including the rules themselves) interact. Taking a fish tank as an example of a system, ‘rules’ might therefore be thought of as the water inside the tank.

For Geels, socio-technical systems and regimes serve as different “analytic dimensions” (Geels and Kemp 2007, p.442). The regime concept addresses the question of how systems *change*, as opposed to how systems *function* (which, Geels suggests, has been the main focus of “the systems of innovation approach”; Geels 2004a, p.899). “Institutions should not just be used to explain inertia and stability,” he writes. “They can also be used to conceptualise the dynamic interplay between actors and structures” (Geels 2004a, p.897). It is worth questioning whether this distinction between system functioning and system change is useful for the purposes of this study.¹⁸ It is suggested that *any* analysis that takes account of the mechanisms of path dependence outlined already cannot be a purely static representation, but will regard *some* degree of change and variability as an intrinsic part of system functioning. Hughes’ definition of momentum involved direction towards system goals and was therefore an inherently dynamic concept.

¹⁸ Geels was focused on system change over a much longer timescale than that used in this study, which may account for the sharper distinction he draws between short-term variability and longer-term (discontinuous) change.

The socio-technical transitions literature defines three main types of system-level change: reproduction, transformation and transition. Continuous change at the level of socio-technical regimes is described as a process of “*reproduction*”, with regimes being in a state of “dynamic stability” (i.e. developing incrementally and cumulatively over time along existing trajectories towards broadly consistent goals defined [and constantly redefined] by the regime; Geels 2004a, Geels and Kemp 2007, p.445). The current study is interested in understanding such processes and the concept of ‘dynamic stability’ usefully encapsulates the notion that, although the goals towards which a system is moving may remain broadly consistent, the system itself will exhibit a degree of change as it progresses towards those goals (even as the goals themselves may be gradually refined).

Meanwhile, change of a more radical nature – discontinuous change – takes the form of either *transition* (which typically results from developments outside of the regime, i.e. from “niches”) or *transformation* (which typically originates from within the regime itself) from one socio-technical regime to another involving a “change in the regime rules that coordinate actions of regime actors, e.g. changes in technical problem agendas, visions, goals and guiding principles, relative costs and incentive structures, regulations and perceptions of opportunities” (Geels and Kemp 2007, p.445). These discontinuous forms of change are more closely associated with changes in system goals, negotiated at the regime level.

Given the huge variety of interacting components that constitute socio-technical systems, some means of categorising these is necessary, for the purposes of analysing processes of system continuity and discontinuity. Markhard and Hoffman, for example, propose a straightforward division of socio-technical systems into a small number of categories of components (Markhard and Hoffman 2016, p.64), namely:

- **Actors**, which includes “individuals, firms and other organisations”
- **Institutional structures**, including “societal norms, technology standards, regulations, user practices, culture, collective expectations etc.”
- **Technologies** and;
- **Resources**, such as “knowledge, human and financial capital, natural resources”.

Although these categories may overlap¹⁹ they may nevertheless provide a simple means of grouping components in order to analyse their interactions. Moreover, where such interactions

¹⁹ e.g. knowledge and human capital will be embedded in human actors; technologies will embody as well as influence technology standards; institutions will be developed by the interaction of actors, technologies, resources, and the institutions themselves, as well as through their own reproduction.

influence the goals and therefore the trajectory taken by a socio-technical system, these categories may provide a means of identifying and characterising the sources of such influence.

3.3.8 Socio-technical Systems and Complementarity Effects

The positive feedback mechanisms associated with path dependence can be incorporated into a socio-technical transitions perspective.

Markhard and Hoffmann developed “a framework to systematically identify different kinds of complementary relationships with a focus on technologies”, defining ‘complementarity’ as occurring, loosely, when the combined value of two or more components is greater than the sum of their values taken individually (Markard and Hoffmann 2016, p.64-65). With an interest in transitions from one socio-technical system to another, Markard and Hoffmann aimed to understand the dynamics of complementarities between system components, which may:

- Change within transitions from one socio-technical system to another
- Serve as a source of stability inhibiting transitions from one system to another
- Act as bottlenecks delaying or preventing the emergence of new socio-technical systems, for example where “essential complementary components may be missing” (ibid. p.64, i.e. potentially giving rise to reverse salients, see 3.3.6).

Their framework is underpinned by the concept of the “focal element” (which can be “a firm, a novel product” or a technology, ibid. p.65). Complementary components are viewed as “‘what else is needed for the focal entity [element] to succeed’. In other words, there is a specific purpose underlying the identification of complementarities” (ibid. p.65). Furthermore, Markhard and Hoffman suggest that: “to identify complementarities we first have to specify what the complementary element is supposed to strengthen” (ibid. p.66). Put differently, their framework identifies complementarities where a component supports the performance of a focal element towards the achievement of system goals and, moreover, there may be a degree of intention²⁰ behind such support.

The framework may be useful for the purposes of the current study (see further 4.2.1), which is interested in understanding the mechanisms by which a system is stabilised (or not). An ability to identify and assess the sources of stability (or the lack thereof) may therefore be useful. Their framework is outlined, critiqued and adapted to the purposes of this study in **Chapter 4**.

²⁰ Markhard and Hoffman’s requirement for “intentionality” is problematic, given that a key characteristic of path dependent processes is that they can take place “behind the backs” of actors (i.e. without intention; Sydow et al 2012, p.155).

3.3.9 Path Creation and Path Constitution

As outlined earlier (**section 3.3.3**) evolutionary theory encompasses a broad range of approaches, united in their conception of technological change as a non-linear process, but distinct in their views regarding the respective roles of economic, technological and social factors within the process of technological change.

For example, critics of the path dependence literature (**3.3.4**) have suggested that it marginalises the role of human agency, arguing instead that the development of paths is better explained as a process of “path creation” (Garud et al 2010). In this view, deliberate or “mindful” actions of agents – as opposed to automatic or “emergent” processes – are regarded as the principal factor determining how paths develop (Garud and Karnøe 2001). Those writing from a path creation perspective often cite the example of the manufacturer 3M’s discovery of a “glue that does not glue”, which led to the development of the ‘Post-it’ note. In this case, they suggest, actors “mindfully deviated from 3M’s routines of developing stronger kinds of glue” (Meyer and Schubert 2007, p.27).

From a path creation perspective, actors’ intentions are therefore a fundamental consideration. Actors often have clear objectives (i.e. which may be thought of as the ‘goals’ that Hughes describes), which they may seek to direct the system towards, as distinct from the system being directed purely through emergent processes towards some arbitrary or unintended outcome.

However, just as path dependence is open to the criticism of overstating the role of emergent processes, so path creation may be criticised for placing too much emphasis on the role of agency. For example, path creation scholars assert that “initial conditions are not given, but rather constructed by actors” (Garud et al 2010, p.769), a view that seems untenable when one considers a dairy farmer, for example, who is unable to influence either the local geography or climatic conditions that he/she must operate within. Actors may envisage goals for themselves or the system, but may not have the power to realise these goals (or may be thwarted by other, more powerful, actors).

A “path constitution” perspective aims to unify these competing path dependence and path creation perspectives, and regards the development of paths as a combination of both emergent and deliberate processes. In developing the concept of path constitution, Meyer and Schubert (2007) draw on Giddens’ concept of “structuration”. Giddens’ approach to understanding the creation and reproduction of social systems combines elements of objectivist perspectives (which position ‘structures’ as the main determinant of social systems) and subjectivist perspectives (which position ‘agency’ as the main determinant of social systems) and he therefore views structure as “both medium and outcome of reproduction of practices” (Giddens

1979, p.5). Therefore, just as structures define the space in which agents can act, so agency constantly redefines and reshapes that space.

3.4 Sociological Perspectives on Technological Change

Given that this study is interested in whether (and how) power contributes towards technological continuity and discontinuity, it may be useful to draw upon social constructivist perspectives on technological change, which have influenced both the socio-technical systems perspectives and path creation perspectives discussed already (Geels 2004b; Garud and Karnøe 2001, p.3).

Leading scholars in the field of the sociology of technology have been either critical of the Dosian perspective as being deterministic (Pinch and Bijker 1987) or accepting of it as being essentially compatible with their own views of technology as a “socially constructed” phenomenon (van den Belt and Rip 1987, p.129). Indeed, van den Belt and Rip were readily able to develop a “sociological extension of the Nelson-Winter-Dosi model” (van den Belt and Rip 1987, p.130), in which they suggest that:

“The occurrence of a technological paradigm can be characterised by the clustering of successful heuristics around an exemplary achievement... the combination of exemplar and cultural matrix forms a technological paradigm, and the further articulation of such a paradigm, partly influenced by the selection environment, leads to a technological trajectory” (ibid. p.134).

MacKenzie and Wajcman suggested that, because paradigms are “exemplars”, one should understand trajectories as being “conditioned by social factors inside and outside the firm” (MacKenzie and Wajcman 1999, p.15). Whereas Dosi ascribes the variety of directions taken within a trajectory to differences in economic and technological trade-offs, MacKenzie and Wajcman ascribe such variety to differences in “social factors”. The two perspectives are not necessarily mutually exclusive.

This section will not focus upon sociological critiques of the Dosian perspective²¹ but upon those elements of social constructivism that can be usefully incorporated into a Dosian perspective in order to locate and account for the action and effect of power within processes of technological change.

²¹ Such critiques appear to centre upon the extent to which the analogy between technological development and evolutionary biology is tenable, or on the “deterministic overtones” that some authors detect within the Dosian approach; see above, 3.3.2

3.4.1 Social Groups, Power and Conflict

Pinch and Bijker's approach to understanding the development of technological artefacts begins with the identification of "relevant social group[s]" (Pinch and Bijker 1987, p.23), members of which "share the same set of meanings, attached to a specific artefact". Because the same artefact may have different meanings for different groups (as the result of "interpretive flexibility"; Meyer and Schulz-Schaeffer 2006), technology – they argue – can be regarded as being "socially constructed" (Pinch and Bijker 1987), through a process of "stabilisation and closure" of "technological frames" (Meyer and Schubert 2007 pp.34-35). Put differently, the various meanings or frames developed by different social groups are in competition with one another, the outcome of such competition depending in part upon the power of those social groups.

This notion of conflicting and contested "meanings" bears much in common with a "pathways approach" towards understanding the governance of complex systems, which suggests that "different actors ... produce particular narratives which frame systems and their dynamics in different ways, promote particular goals and values, and justify particular pathways" (Leach et al 2010a, p.369).

Although they are critical of the Dosi's view, Pinch and Bijker's approach is also in some ways reminiscent of Dosi's, suggesting that technological change begins with the definition of a "relevant" problem:

"In deciding which problems are relevant, the social groups concerned with the artefact and the meanings that those groups give to the artefact play a crucial role: A problem is defined as such only when there is a social group for which it constitutes a 'problem'." (Pinch and Bijker 1987 p.22-23)

From this starting point, the analysis of processes of technological change involves first identifying all relevant social groups, and then describing these groups "in order to define better the function of the artefact with respect to each group" and "the problems each group has with respect to that artefact" (ibid. p.28), namely, the ways in which the group 'frames' the technological problem and solution. Relevant characteristics for describing social groups include "power or economic strength" (ibid.). By placing social groups at the centre of the analysis, and considering their power (economic or otherwise), the issue of *conflict* comes to the fore as different groups may develop conflicting meanings for technological artefacts, based around the different functions that those artefacts perform for them.²² Further, groups may

²² Dosi might describe this in terms of "different relevant variables" (Dosi 1982, p.148).

have conflicting future requirements of those artefacts, and may therefore prioritise different technical problems and solutions as a result (ibid.).

This approach is both compatible with – and provides a possible extension to – the socio-technical systems perspective already described. It is compatible in the sense that ‘social groups’ provides a clear counterpart to the category of ‘actors’, and that technological change involves the establishment of ‘goals’. It offers an extension insofar as it regards the determination of ‘relevant’ problems as an inherently *contested* process. The notion of ‘conflict’ – or of competition between alternative views of ‘progress’ (which, indeed, might be thought of as the opposite of ‘complementarity’; Markhard and Hoffman 2016, p.64) – introduces an element of normativity to the analysis of processes of both continuous and discontinuous change.

In this view, technological change is not simply the result of firms executing various technological and economic trade-offs in order to conform with system goals. Regimes are not merely the “constellation of beliefs, values, techniques, and so on shared by the members of a given community” (MacKenzie and Wajcmann 1999, p.13). Instead, the trade-offs executed by firms (and the ‘relevant variables’ and goals themselves) may be related to the contested nature of technological problems (and solutions) at the actor-level (i.e. different actors may have conflicting definitions of problems and solutions, and therefore trade-offs may result not only from the constraints presented by current configurations of technologies, actors, resources and institutions but, further, from constraints presented by the meanings or frames developed by groups of actors, which are based in turn upon actors’ knowledge of and experience with the use of technological artefacts, and the beliefs they derive from such knowledge and experience).

Therefore, when considering complementarity effects, for example, it may be expedient to incorporate an account of actors’ beliefs (which may be regarded, within socio-technical systems, as “cognitive rules”, a subcategory of institutions; Geels 2004a, p.904-5; see **Table 3a**), as well as the extent to which such beliefs “promote particular goals and values” (Leach et al 2010a, p.369); i.e. the extent to which they support “normative rules” (see **Table 3a**). The issue of power therefore becomes a key element of such an analytical approach, because the beliefs of the most powerful actors seem likely to exert the greatest influence upon how problems are both defined and solved.

Moreover, this perspective does not confine conflict to transition or transformation contexts. While socio-technical transitions perspectives regard socio-technical regimes as consisting of the institutions, rules and norms that govern socio-technical systems, and view socio-technical systems as “the result of activities of social groups which (re)produce them” (Geels 2004b, p.33),

the notion of *reproduction* as an *inherently contested process* (or of conflict between social groups at the regime level) is not always at the forefront. Instead, the literature has tended to focus more heavily on contestation within *transitions* contexts (where the locus of conflict is typically at the intersection of niches and regimes). However, the foregoing implies that reproduction may be viewed as a process of ongoing negotiation between various social groups of differing powers, which develops towards stabilisation and closure around “technological frames” (Meyer and Schubert 2007 pp.34-35).

Table 3a: Varying Emphasis: Three Kinds of Rules/Institutions

	Regulative	Normative	Cognitive
Examples	Formal rules, laws, sanctions, incentive structures, reward and cost structures, governance systems, power systems, protocols, standards, procedures	Values, norms, role expectations, authority systems, duty, codes of conduct	Priorities, problem agendas, beliefs, bodies of knowledge (paradigms), models of reality, categories, classifications, jargon/language, search heuristics
Basis of compliance	Expedience	Social obligation	Taken for granted
Mechanisms	Coercive (force, punishments)	Normative pressure (social sanctions such as ‘shaming’)	Mimetic, learning, imitation
Logic	Instrumentality (creating stability, ‘rules of the game’)	Appropriateness, becoming part of the group (‘how we do things’)	Orthodoxy (shared ideas, concepts)
Basis of legitimacy	Legally sanctioned	Morally governed	Culturally supported, conceptually correct

Source: Geels 2004a, p.905, citing Scott 1995, pp.35, 52

Finally, this conception builds upon the notion that a farm’s ‘history’ (as a socio-technical system) influences its future development, incorporating the possibility that this history may be influenced by (and in turn may influence, or provide a justification for) a farmer’s beliefs about the ‘right way’ to farm, both in the past, present and future. Social constructivist and pathways perspectives may therefore provide a useful complement or extension to a socio-technical systems perspective.

3.5 Further Approaches to Understanding Power

This section examines the notion of power in further detail, with a view to informing a conceptual approach towards the identification and characterisation of the power of various

relevant actors, as well as the ways in which such power is exercised and its effect upon technological change. This will serve to develop an understanding of whether (and how) buyers are able to influence patterns of technological change exhibited by farms (which will be incorporated into the analytical framework outlined in **Chapter 4**).

A comprehensive review of the literature on theoretical approaches to understanding power is beyond the scope of this section. Instead, it takes as its starting point conceptions of power that have influenced thinkers in the fields of evolutionary and social constructivist perspectives on technological change, discussed already. Notably, the socio-technical systems and transitions literatures have been influenced in their understanding of power by the work of Michel Foucault, with some transition theorists' conceptions of power drawing upon Foucault's "view of power as a structure through which agents must act" (Smith et al 2005, p.1504; Geels and Schot 2007; Geels 2010; Elzen et al 2011; Tyfield 2014). This informs their suggestion that "incumbent regimes constitute one aspect of this kind of power" (Smith et al 2005, p.1504).

Within socio-technical systems, 'institutions' (or 'rules') may be viewed as a significant component of such 'structures' of power, and one that merits closer attention. Indeed, if dairy farms as socio-technical systems are viewed as being 'nested' (Smith et al 2005) within a broader socio-technical system and its underlying regime – namely, the value chain for milk – then understanding the operation of power, as it relates to the functioning of these socio-technical systems, must necessarily involve *an examination of mechanisms for the governance of this broader value chain* (i.e. some consideration of both the rules by which the value chain is governed and the extent of actors' involvement in the development and enforcement of those rules).

With this in mind, a consideration of the different categories of rulesets (regulative, cognitive and normative) introduced above (**Table 3a**), within which power may be embodied or expressed, provides a useful basis upon which to ground the theoretical perspective on power to be applied within this study.

As outlined above (**3.4.1**), a social constructivist perspective encourages the analyst to regard the reproduction of socio-technical systems as being an inherently dynamic and contested process and, moreover, to take into consideration the contrasting approaches of different actor groups towards the 'framing' of technological problems and solutions. By reference to the different categories of rules defined in **Table 3a**, it can be seen that such perspectives are therefore focused upon cognitive rulesets (i.e. how actors *think* about technological problems), albeit these may be underpinned by, or indeed may inform, normative rulesets (loosely how actors *feel* about the world).

However, in order to make sense of the ways in which the contrasting cognitive and normative rulesets of different actor groups interact with each other, it is suggested that these cognitive and normative rulesets must be viewed within the context of an established structure of *regulative* rules that govern the system being studied. For example, the beliefs and objectives of social movements for change may be underpinned by cognitive or normative rulesets, but these may only be fully understood when viewed within the context of the established system of regulative rules that such social movements are aiming to change. Campaigns for safer road traffic laws, for example, cannot be understood or evaluated without an understanding of the existing regulative framework of road traffic laws.

This implies that, when adopting a theoretical perspective of technological change that combines elements of evolutionary and social constructivist approaches, it would also be useful to incorporate a theoretical perspective of power that defines extant power structures by reference to regulative rulesets. This may illuminate the technological frames developed and deployed by different actor groups.²³ Moreover, it may highlight *where* power lies within the value chain (i.e. who makes and enforces the regulative rules), the *extent* of such power, and the mechanisms through which it is exercised. Indeed, given that the research question is focused on the exercise of power by buyers (both processors and retailers) and the resulting influence on dairy farmers and their technological trajectories, answering this research question requires a consideration of not only cognitive and normative rulesets, but of the *regulative* rules (e.g. contracts for the sale of milk, milk prices etc) through which power relations between buyers and farmers are formally expressed.

One such perspective, which has been applied extensively to the analysis of the food system, is a “global value chains” approach.

3.6 Value Chain Analysis

The literature on global value chains (GVC) is of interest to this study not only because it has focused on the functioning of supply chains for services and goods, with a strong emphasis on value chains for agricultural commodities (Vagneron et al 2009; Kaplinsky and Fitter 2004). It is, further, of interest as it:

- Presents potential conceptual tools relating to the analysis of regulative rules discussed above (3.4 – 3.5), and

²³ This is not to disregard the importance of cognitive and normative rules, or their relationship with regulative rules, but merely to observe that (from the point of view of answering the current research question) regulative rules may be placed to the fore, not least because they can be readily elicited and accurately specified.

- Is focused upon the role of “lead firms” or “dominant parties” that co-ordinate the activities of value chains through the development and enforcement of such regulative rules (Kaplinsky and Morris 2001 p.8). This means that “power asymmetry is ... central to value chain governance ... [because] there are key actors in the chain who take responsibility for the inter-firm division of labour, and for the capacities of particular participants to upgrade their activities” (ibid. p.29). This theoretical / analytical perspective is of particular relevance to the present study, in the light of the policy context outlined in **Chapter 2**.

The GVC literature regards a value chain as “the full range of activities that firms and workers perform to bring a product from its conception to end use and beyond” (Gereffi and Fernandez-Stark 2011, p.4). By analysing the *entire* chain, a GVC approach aims to understand, among other things, how returns are distributed along the chain, from upstream producers to downstream consumers (i.e. the “distribution of benefits”, Kaplinsky and Morris 2001, p.14). Moreover, GVC studies are often interested in identifying which activities in the chain are “subject to increasing returns, and which are subject to declining returns” (ibid. p.22) in order to ascertain which links in the value chain may require additional (i.e. policy) support or control.

Obtaining an understanding of where power lies within value chains, and the mechanisms through which it is exercised, is fundamental to answering many of these questions. The GVC literature has therefore developed a number of analytical tools for identifying and characterising the action and effect of power within value chains, which may be useful for the purposes of this study. These are outlined in the following sections.

3.6.1 Value Chain Mapping

Mapping involves the construction of a (typically visual) representation of:

- **Physical flows** of materials, goods, and services along the value chain, from raw inputs to final products and waste
- The **activities** taking place along the value chain, for example the points at which materials are converted from one form into another (i.e. where value is added)
- **Distributional outcomes**, or the points along the chain at which value is extracted. The process of mapping value chains “analyses the way in which particular firms, regions and countries are linked to the global economy ... [which] will determine to a large extent the distributional outcomes of global production systems” (Kaplinsky and Morris 2001, p.41). Put differently, mapping offers a means of identifying “who wins” within a value chain and can, moreover, provide an indicator of which participants in the value chain are “lead firms” (ibid. p.8).

3.6.2 Rent, Scarcity and Barriers to Entry

Although value chain mapping can provide an indication of which participants derive the greatest benefit from value chain activities, it may only serve to *describe* the distribution of benefits as opposed to offering a full explanation for such outcomes. Therefore, it may not be enough to simply state that those actors who secure the lion's share of returns from the value chain are the most powerful (although this may often be the case), or to conclude that their ability to capture that value is exclusively the result of their greater power. Instead, it may also be necessary to take some account of other, often structural, factors that may contribute towards distributional outcomes.

The fact that some activities in a value chain are better rewarded than others can be partly explained using the concepts of "rent", "scarcity" and "barriers to entry" (Kaplinsky and Morris 2001, p.25, p.45). Rent "arises from the possession of scarce attributes" (Kaplinsky and Morris 2001, p.25, p.45). High barriers to entry may enable parties to secure rents, insulating them from competition and the associated downward pressure on incomes. Barriers to entry may include, for example, access to resources (e.g. raw materials or land), information or skills; high costs (such as plant, machinery, or labour); or regulatory requirements (such as minimum production standards). Where barriers to entry are low, the resulting competition will erode participants' ability to secure rents.

The degree of specialisation within the supply chain is a further relevant factor that can inhibit participants' ability to secure rents. As the size of the market increases, activities at each link in the value chain will tend towards a higher degree of specialisation (Kaplinsky and Morris 2001, p.9). Firms that specialise in a narrow function within a particular link of a value chain (dairy farms, for example) can become increasingly vulnerable (ibid. p.19), particularly when they are engaged in activities that add little value, which typically have low barriers to entry, meaning that it is easy for competitors to enter the market. Given the global nature of many value chains, increased competition may result from new market entrants from overseas jurisdictions in which operating costs (for example, those associated with labour or regulatory requirements) are lower.

3.6.3 Conditions of Value Chain Governance

From a GVC perspective, power is regarded as an element of broader "value chain governance" which "concerns not just the power to control what is happening in a value chain, but also the rules that determine how the game is played" (Van Dijk and Trienekens 2012, p.19). GVC scholars have suggested that the governance of global value chains can be understood by

reference to four analytic dimensions that are typically used for characterising conditions of civic governance (Kaplinsky and Morris 2001, p.67), namely:

- The **separation of powers**, which refers to the distinction between legislative (rule making), judicial (rule enforcing) and executive (rule implementing) functions within the governance of civil society. Where two or more of these functions are performed exclusively by a single participant in the chain, this may indicate a concentration of power.
- The **capacity to sanction behaviour** and **the effectiveness of sanctions** (ibid., p.31, 36, 72) – Power within a value chain resides with those actors that enforce the rules. Adherence to rules may be achieved by (a) the threat of punitive sanctions for non-compliance, or (b) the provision of rewards for compliance. Value chain analysis may consider the effectiveness of such sanctions.
- **Legitimacy (or trust)** – In civic governance, governors are regarded as having legitimacy when they enjoy popular support. Kaplinsky and Morris therefore draw a distinction between democratic systems of civic governance, which may be viewed as ‘legitimate’, and non-democratic systems, which may not. They suggest that the closest proxy to this within the governance of global value chains is the concept of “trust”, and that legitimacy within value chains corresponds to “the degree of trust between different parties, and particularly of the ‘governor’” (ibid. p.32). Where trust is low “suppliers are frequently changed to pursue short-term price advantages and failure to conform with the wishes of the governor leads to the rapid sanction of exclusion from the chain” (Kaplinsky and Morris 2001, p.32; therefore, there is a relationship between trust conditions and the application, or threat, of sanctions). By contrast, a chain characterised by longer-term relationships may possess a higher level of trust. Kaplinsky and Morris propose a number of “data points” for assessing conditions of trust within value chains (ibid. p.73), as follows:
 - “the length of contracts
 - the nature of the ordering procedure
 - the nature of the contractual relationship
 - the modes of inspection used in accepting incoming materials
 - the degree of dependence²⁴ which firms have on each other

²⁴ Conditions of low trust may be indicated where a “supplier has many customers, and customer has multiple sources” (Kaplinsky and Morris 2001, p.74). Rather than using the term ‘dependence’, hereafter this study will use the term ‘reliance’, for the avoidance of confusion with the term ‘path dependence’ (3.3.4).

- the types of technical assistance which flow along the chain
- the nature and methods of communication along the chain
- the determination of prices
- the nature of credit extended along the chain especially to exporting firms
- the modalities of payment to outsourced informal economy producers”

Assessing trust therefore requires some consideration of the basis upon which, and frequency with which, relationships between chain participants are reviewed, as well as the terms of those relationships – including the type of sanctions within the chain and how they are enforced – as articulated, for example, within contracts.

Returning to the three rule types introduced above (**Table 3a**), it will be appreciated that the rules indicated by these data points are therefore regulative in nature, rather than cognitive or normative, and reflect broadly the formalised terms under which chain participants transact business, rather than the ways in which participants think or feel about such relations. Therefore, trust, for the value chain analyst, has a narrower meaning than in its popular, day-to-day use (in which it may have a distinctly normative or cognitive dimension). Instead, within the context of the analysis of value chain governance, ‘trust’ may be viewed as representing the degree of certainty, assuredness or confidence that value chain participants have in the continuous, reliable and predictable operation of the value chain, with participants regarding reliable operation of the value chain as ‘good’ in the sense that it benefits the functioning of their business, rather than in the sense that it has intrinsic moral value.

In this regard, ‘trust’ may be viewed as an imperfect proxy for ‘legitimacy’. Indeed, in the context of civic governance (upon which Kaplinsky and Morris base their conceptual approach to value chain analysis) legitimacy has both a normative, cognitive and regulative dimension. The legitimacy of democratic institutions derives not simply from a popular acceptance of formal regulative architecture (e.g. democratic institutions and processes etc) but from an acceptance and endorsement, at a cognitive and normative level, of the very concept of democracy. If trust is an imperfect proxy for legitimacy, this may have implications for the analyst, discussed further below (5.2.6).

- The **depth and pervasiveness** of a system of governance refers to the extent to which the rules governing the value chain affect the activities of participants. ‘Depth’ refers to “the extent to which [governance] affects the core activities of individual parties in the chain” as opposed to “peripheral operations” (ibid. p.32). For example, production

standards may generally be regarded as being deeper than product standards, because they place restrictions upon the activities of participants rather than merely the outcomes of such activities. Pervasiveness refers to “how widely ... power is exercised” (Kaplinsky and Morris 2001, p.32). For example, one may distinguish between system governors who have the power to enforce rules applying to all chain participants, and those that have the power to enforce rules applying to only a small subset of participants (e.g. the distinction between “private” and “public” standards). “In many cases chains may have more than one rule-setting lead-firm, so the issue is one of whose rules-agenda is heard most loudly” (ibid. p.74).

3.7 Research Question

The foregoing review provides a language and a set of conceptual tools that serve to further refine the broad research agenda outlined at the beginning of this thesis (**Chapter 1**), resulting in the following research question:

In which ways, and through what mechanisms, does buyer power influence the reproduction of farm-level socio-technical systems for the agricultural production of liquid milk in the UK?

The next chapter will outline an analytical framework derived from the theoretical materials considered above, which will be used to answer this question.

Chapter 4: Analytical Framework

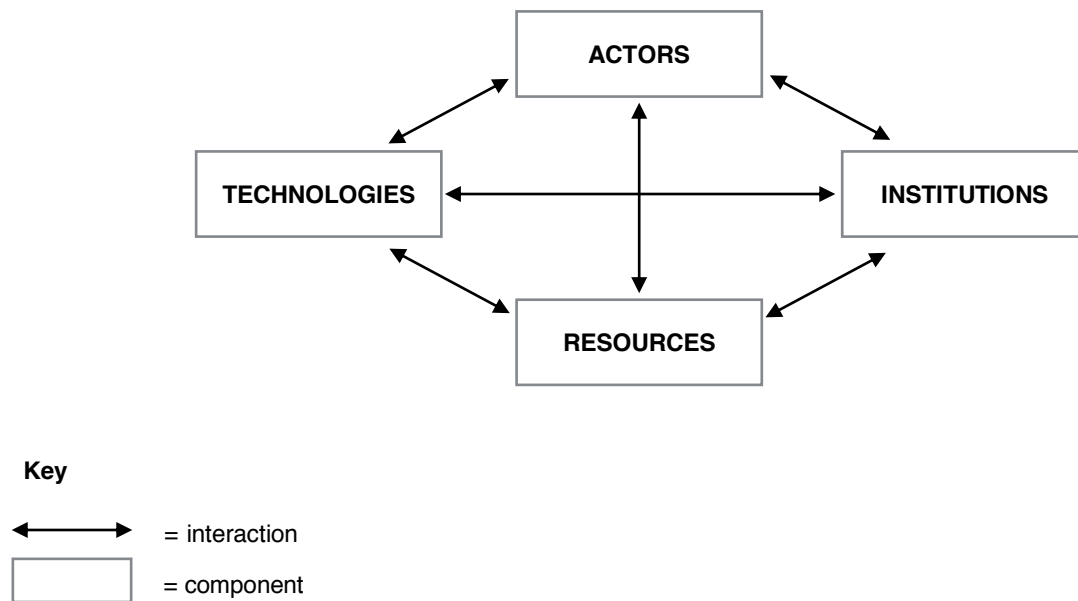
This chapter outlines an analytical framework derived from the theoretical materials reviewed in **Chapter 3**, which will be used (in **Chapters 7 to 9**) to characterise patterns of technological change exhibited by UK dairy farms, and to determine the influence of buyer power upon such patterns.

The framework draws on three streams of literature: evolutionary theories of technological change; the study of global value chains (GVC); and the theory of the social construction of technology (SCOT). Basing the framework around an evolutionary perspective of technological change offers potential advantages over ‘linear’ perspectives, in which technological change results from variations in a single factor input, or is driven by *either* ‘market pull’ or ‘science push’ (3.3). Instead, change (and inertia) will be viewed as the product of interactions and feedbacks between a number of interrelated technological and non-technological components, categorised as actors, technologies, resources and institutions (Markhard and Hoffman 2016 p.64). Together these comprise a ‘socio-technical system’ underpinned by a ‘socio-technical regime’ (3.3.6). Due to these ongoing interactions, socio-technical systems exhibit ‘dynamically stable’ ‘reproduction’²⁵ along established technological trajectories (3.3.7), alternating between periods of relatively stable ‘path dependent’ change and periods of more disruptive change.

However, evolutionary – or ‘coupled’ – models have been criticised for their ‘circular’ character, meaning that the practical value of such models may be limited because all elements of the model influence all other elements, thereby compromising the ability to “distinguish between more and less important aspects of socioeconomic and technological processes” (Millstone 2010, p.294; **Section 3.3.2**). Even if, in reality, “everything is interconnected with everything else” (see **Figure 4a** for a visual representation of this), it is desirable for the purposes of analysis to “differentiate more from less important links and interdependencies” in order to “indicate the main drivers of stability and change” (ibid.). This criticism highlights: (i) the need to select a starting point for the analysis and the sequence it will follow; and (ii) the need to determine the interactions that are most ‘important’ for the purposes of this analysis (4.1). Conceptual tools that will be used to examine these interactions – drawn from GVC and SCOT – will be elaborated upon in **Section 4.2**.

²⁵ Reproduction encapsulates change within and between different clusters of “possible technological directions” taken within a technological trajectory (Dosi 1982, p.154). Transformations and transitions (i.e. change from one technological trajectory to another) are outside of the scope of this study.

Figure 4a: A Coupled Model of a Socio-technical System



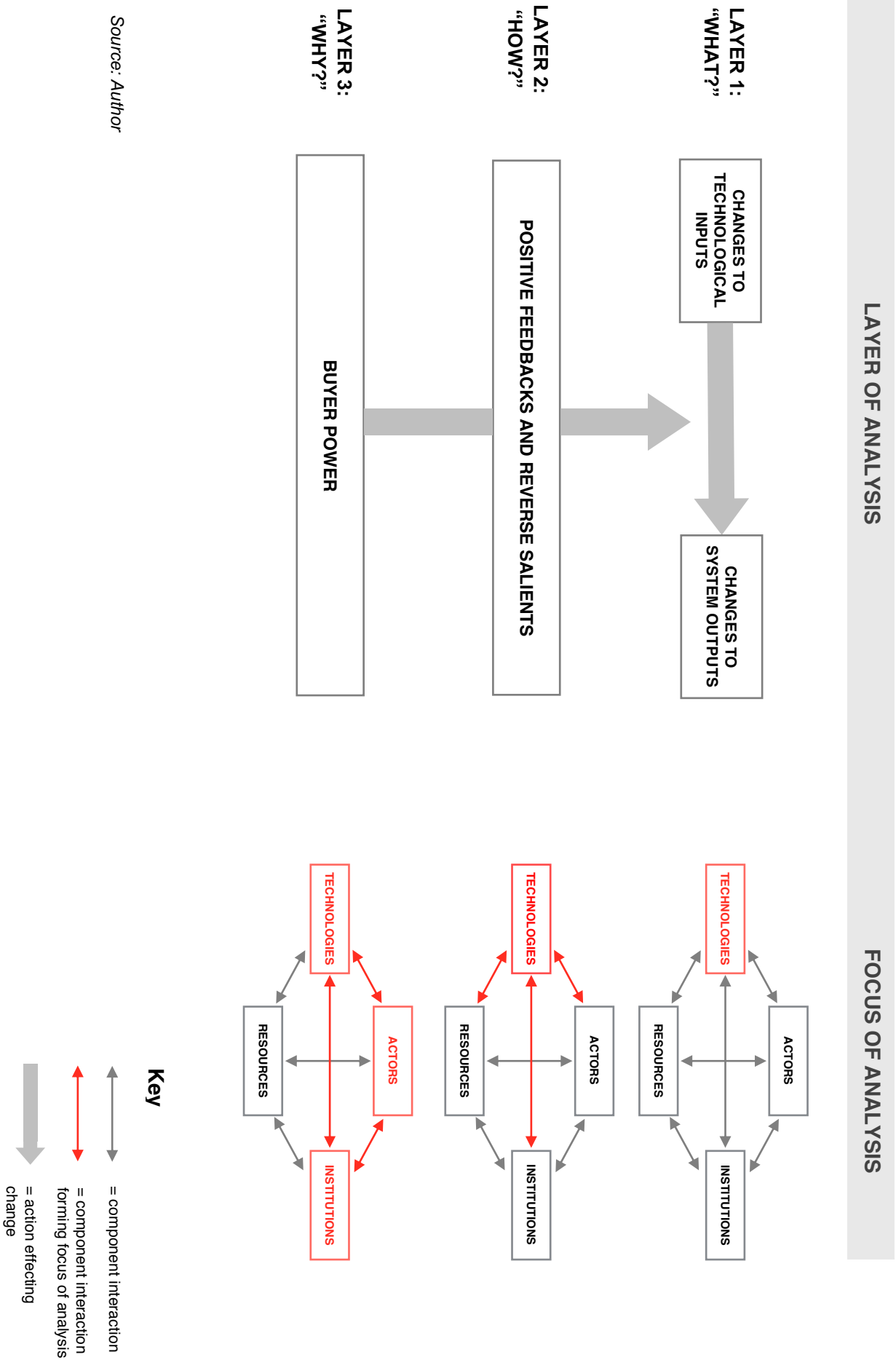
4.1 Determining a Starting Point for the Analysis and 'Important' Interactions

This study aims to understand the ways in which (and mechanisms through which) buyer power influences the reproduction of socio-technical systems for the agricultural production of liquid milk in the UK. Put simply: "(How) do powerful buyers influence technological change amongst UK dairy farms?"

This objective implies a logical starting point for the analysis. Before the influence of buyers upon farms can be considered it is first necessary to describe farms as socio-technical systems within which these interactions take place, and to consider the positive feedbacks that explain how these configurations may be stabilised and disrupted. This is important not least because the study is based on a 22-year 'snapshot' of a period of longer-run technological change (see 4.4); because 'history matters' it is necessary to contextualise the interactions that form the focus of the study.

With regard to which interactions will be viewed as 'important', the analysis will adopt a 'layered' approach, illustrated in Figure 4b. Different components and interactions will be focused upon at different layers of the analysis, through the deployment of different analytical 'lenses'. In Figure 4b, the components and interactions highlighted in red are those that will be placed in the foreground, while other components and interactions will be placed in the background (although not completely overlooked).

Figure 4b: A Layered Analytical Approach



In the same way that binocular vision permits the perception of depth by superimposing two overlapping fields of view, it is envisaged that iterating between these different analytical lenses will yield a three-dimensional depiction of processes and patterns of technological change. The conceptual tools that will be used at different layers of the analysis are detailed in **Section 4.2**.

The layers of this framework are described in further detail, as follows:

- **Layer 1: Describing and characterising socio-technical system reproduction** (i.e. "*What is happening?*"). Individual farms will be described as socio-technical systems – configurations of interacting technologies, actors, institutions and resources – ‘nested’ within a broader, sector-level socio-technical system (the value chain for liquid milk; Smith et al 2005, p.1493). The ‘dynamically stable’ functioning of socio-technical systems will be described at the farm level by reference to variations in technological inputs (and their associated system outputs) across a range of relevant parameters (detailed in **5.1.2**). In this way, farms will be categorised as belonging to one of three ‘clusters’, or different possible technological directions within the technological trajectory for dairy farming (Dosi 1982, p.154), corresponding to three system ‘types’: intensive, intermediate, and extensive (**5.1.2**). Rates of change within, and changes between, these clusters will be characterised by reference to changes in relevant inputs across the duration of the study.
- **Layer 2: Identifying the mechanisms underlying system functioning** (i.e. "*How is it happening?*"). Examples of the action or inaction of positive feedbacks or reverse salients will be identified (**4.2.1**). These are the mechanisms that *explain* the functioning of socio-technical systems described using layer 1, and which explain stability (associated with rates of change) and disruption (associated with changes in direction) within these systems. This will involve both an analysis of interactions between technologies, and an analysis of interactions between technologies and other components (actors, institutions and resources).
- **Layer 3: Determining the role of buyer power** (i.e. "*Why is it happening?*"). The dynamic stability of the systems described in layer 1 is a result of the inherently contested nature of socio-technical system reproduction. The variations in technological inputs described in layer 1 can be regarded as ‘trade offs’ that are made in order to direct systems towards ‘goals’ (Dosi 1982, p.154; Hughes 1983, p.15). Layer 3 will provide an *explanation* of *why* the changes described in layer 1 occur (i.e. this offers a

means of distinguishing between changes that have occurred under the influence of buyer power, and those that have not).

This will involve a consideration of whether the 'goals' towards which socio-technical systems are moving 'correspond' with the goals towards which buyers are aiming to direct them and, if so, 'how?' and 'why?' (see further, 4.2). Socio-technical system inputs and outputs (as a proxy for 'system goals') will be compared with buyers' demands (expressed through contracts, milk prices and other relations with farmers, and serving as a proxy for the goals towards which buyers are aiming to direct systems). The direction of the relationship between system goals and buyer demands will be illuminated by a consideration of the conditions of value chain governance (with buyer power acting either through or against the positive feedbacks identified in Layer 2), and will be further enriched by a consideration of how and whether these conditions support processes of 'stabilisation and closure of technological frames' (Pinch and Bijker 1987, p.23; Meyer and Schubert 2007 p.35). This will involve a consideration of the interplay between the various regulative, normative and cognitive rules that characterise the value chain.

This framework will be applied at the farm level of analysis. It may be possible, however, to draw some inferences with regard to sector level processes by aggregating and/or comparing these farm-level responses (for example, comparing the response of different farms to similar demands may reveal that different farms respond differently to similar demands, depending on their 'starting point' relative to the goal that buyers are seeking to direct them towards; see 4.2.2).

4.2 Conceptual Tools

Concepts drawn from evolutionary theories of technological change; global value chains (GVC); and the social construction of technology (SCOT) will be used alongside each other at various layers of the analysis in order to illuminate the influence of buyer power within socio-technical system reproduction.

The framework draws upon areas of common ground shared by evolutionary theories (e.g. Dosi 1982), large technical systems perspectives (e.g. Hughes 1983), and social construction of technology (SCOT) approaches to the study of technological change (Pinch and Bijker 1987) in order to explain the involvement of actors (buyers and farmers) within processes of technological change. These different perspectives – while emphasising to varying degrees the

roles of structure versus agency – broadly agree that the reproduction of socio-technical systems involves the definition, by actors, of ‘relevant’ problems and of approaches to the solution of these problems (with the solution of problems representing the ‘goal’ of technological change). Moreover, the definition of problems and solutions is shaped and constrained, to some extent, by current configurations of technologies.

4.2.1 Positive feedbacks and Reverse Salients

The mechanisms that explain the functioning of socio-technical systems will be examined by reference to the following positive feedback effects resulting from interactions between system components (both between technologies and other technologies and between technologies and other components, including actors, institutions and resources; layer 2):

- **Complementarity effects**, which occur when the combined value of two or more components is greater than the sum of their values taken individually (Markard and Hoffmann 2016, p.64-65) and **reverse salients**, which occur where “essential complementary components may be missing” (ibid. p.64) meaning that “a component of the system does not march along harmoniously with other components” and “growth of the entire enterprise is [thereby] hampered” (Hughes 1983, p.79).

For Markhard and Hoffman, complementarity effects occur where one system component supports the performance of a “focal element” towards the achievement of system goals (Markhard and Hoffman 2016, p.65). Such relationships may be unilateral (i.e. one way) or bilateral (i.e. both elements supporting each other’s performance), with the latter being regarded as stronger / more intense (ibid.).

I will apply a broader definition of complementarity effects within this study. Instead of specifying a single focal element, which other components are “supposed to” support, I will adopt a more flexible approach, identifying complementarities wherever the interaction between two (or more) components improves the performance of *any* of the interacting components – *or* the functioning of the system as a whole – in support of the achievement of established system goals. Moreover, I suggest that complementarities may occur between more than two system components and may therefore be *multilateral*.

I will also regard components that have a negative effect on the performance of other components with regards to the achievement of (current) system goals as *competing* with those other components, potentially resulting in the formation of new system goals. ‘Reverse salients’ will appear where complementary components are not readily

available (which may often accompany the introduction of a new technological component and / or a redefinition of system goals) which may prompt technological search in response to these reverse salients.

- **Investment and learning effects** resulting from “the accumulation of specialised, but non-transferable stocks of investment or knowledge” (Dobusch and Schußler 2012 p.623). These will refer to the physical, financial, and human capital embodied in stocks of “hardware” (e.g. machinery, buildings, infrastructure) and “software” (e.g. training, skills, ‘tacit’ knowledge, experience associated with farm processes or the operation of hardware; Cowan et al 2000), which are regarded as specialised and “non-transferable” (i.e. they are specific to a particular function associated with the current system; Dobusch and Schußler 2012 p.623);
- **Co-ordination effects** “which confer advantages to ‘going along’ with other economic agents taking similar action” and **expectation effects** “where increased prevalence enhances beliefs of further prevalence” (Arthur 1994 p.112). For example, such effects may arise as a result of the creation of industry ‘best practice’ or standards and may therefore be of particular interest in the context of understanding the influence of powerful buyers upon technological development at the sector level.

Chapter 5 will consider the technologies used in dairy farming. The interactions between these technologies can be understood by reference to these effects.

4.2.2 Dimensions of Value Chain Governance

Because this study regards technological change as ‘progress towards goals’, one approach towards identifying the influence of buyers upon socio-technical system reproduction is to consider *whether* the goals towards which systems are moving correspond with the goals towards which buyers are aiming to direct them and, if so, *how* and *why*.

‘Progress towards system goals’ can be inferred from the inputs and outputs associated with socio-technical systems (layer 1, 4.1), with different configurations of technological inputs (and resulting outputs) progressing towards different system goals. Meanwhile, the goals towards which buyers are aiming to direct systems can be inferred from ‘buyers’ demands’, expressed through milk prices, contracts, or other relations with farmers.

Where there is a lack of ‘correspondence’ between system goals and buyers’ demands this may indicate that buyers have failed to influence the reproduction of farm socio-technical systems. However, where there is a close correspondence between ‘progress towards system goals’ and ‘buyers’ demands’ the direction of the relationship between system outputs and buyers’ demands may be unclear. It may be that either:

1. Buyers have influenced socio-technical system reproduction
2. Buyers’ goals have themselves been influenced by socio-technical systems, or that
3. Socio-technical systems and buyers have influenced each other.

Determining the direction of the relationship between system outputs and buyers’ demands therefore involves some assessment of actors’ power relative to the broader structure of the system. The positive feedback mechanisms (4.2.1) that contribute towards the stability or instability of that structure identify points of strength (e.g. complementarities or investment effects) and weakness (e.g. reverse salients) within that structure. These mechanisms may act either in opposition to, or in support of, the exercise of buyers’ power (i.e. power can be exercised either through or against these mechanisms).

Concepts drawn from the GVC literature may further illuminate the extent of buyer power and the direction of the relationship between buyer goals and system outputs, outlining conditions under which, and mechanisms through which, buyers exercise power in order to achieve compliance with their demands. The analysis will consider:

- The **sanctions** (both positive and negative, including the power to exclude) that buyers impose in order to encourage compliance with their demands. Where changes in socio-technical systems have followed the imposition of sanctions a causal relationship may be inferred (illuminating point number 1, above). When considering the impact of sanctions the analysis will consider the timing of changes in buyers’ demands compared with the timing of changes in socio-technical systems. With regard to timings, buyers’ goals may not correspond completely with the system goals due to time lags or imperfect overlaps between the two, not least because buyers’ goals may change (potentially with greater speed and frequency than technological configurations).
- The **depth and pervasiveness of rules**, or the extent to which the rules that buyers seek to impose affect farms’ “core’ activities” and of “how widely ... power is exercised” (Kaplinsky and Morris 2001, p.32). Identifying ‘correspondence’ between buyer demands and system goals requires some consideration of the degree of differentiation between buyer demands and established system goals. This is because a variety of ‘solutions’ to problems may be possible (i.e. alternative ways of progressing towards

the same goal, as evidenced by the existence of different clusters) and the responses of farms to buyer demands may therefore vary according to which cluster they inhabit. The depth and pervasiveness of rules will therefore vary amongst the different clusters identified in layer 1 and the diverse positive feedbacks associated with these (layer 2).

Further, understanding how farms have developed, and attributing this to the action (or inaction) of buyer power involves not only an examination of progress made towards goals, but also some comparison between farms' 'starting points' and 'end points'. If a farm exhibits relatively modest changes across the period of the study this might indicate that either (a) it has not been influenced by buyer power, or (b) the technologies that it deployed at the outset of the study, and the ways in which these were configured, already supported progress towards the goals similar to those envisaged by the buyer. In this case buyer power may influence the *rate* of change (within a cluster) rather than the direction of change (between clusters).

- **Trust (and the separation of powers)** – As outlined above (3.6.3), participants within value chains characterised by high levels of trust have confidence in the continuity, reliability and predictability of the operation of the value chain. Value chains characterised by higher levels of trust engender longer, more collaborative relationships between participants in the chain. Such conditions hold the potential for buyers to both influence and be influenced by socio-technical systems. Conditions of low trust are characterised by shorter, unilateral relationships. Such conditions are associated with buyers influencing farms' socio-technical systems as opposed to being influenced by them. Conditions of trust may therefore illuminate points 2 and 3, above.

Chapter 5 will comprise a review of the power relationships within the dairy value chain, the results of which will be used to describe in greater detail how the above concepts will be applied within the analysis (5.2.6).

4.2.3 Stabilisation and Closure of Technological Frames

Where value chains have been distinguished by reference to conditions of trust, thus revealing either bilateral/collaborative or unilateral/non-collaborative buyer-farmer relationships, these actor-actor interactions (and their outcomes) will be further illuminated using the concept of "technological frames", drawn from the study of the social construction of technology (SCOT). Put differently, whereas conditions of trust may describe the nature of farmer-buyer

relationships by reference to regulative rules, this depiction will be supplemented by reference to the normative and cognitive rulesets developed and deployed by these actor groups. This analytical lens may provide a further explanation of the direction of the relationship between system outputs and buyer demands (points 2 and 3, above; 4.2.2) and, moreover, supplement the consideration of buyers' power relative to the structure of the system (4.2.2) with a narrower consideration of buyers' power relative to other actors in the system (namely, farmers). Collaboration – where buyers' and farmers' frames are supportive of each other – may result in increased rates of change.

The SCOT literature suggests that different groups of actors attribute different 'meanings' or develop different 'frames' for technologies, related to the 'relevant problems' that they believe technology should solve, the approaches that should be taken to solving these problems, and therefore the goals towards which they believe technological systems should be directed (3.4.1). Alternative ways of progressing towards the same goal (as evidenced by the existence of different clusters) would be understood from a SCOT perspective as deriving from "interpretive flexibility" or "flexibility in how people think of or interpret artifacts but also ... flexibility in how artifacts are *designed*" (Pinch and Bijker 1987 p.34). Through a process of contest or negotiation actors converge upon "collective stabilisation and closure" around technological frames (Meyer and Schubert 2007, p.35).

The framework will consider this process of frame stabilisation and closure, which involves identifying the frames developed by different groups of actors. Farmers' frames can be inferred to some extent from the socio-technical systems that they use (i.e. they will be embedded in the 'system goals' identified in layers 1 and 2 of the analysis, see above, 4.2).

However, a richer depiction of farmers' frames can be drawn from the supporting statements that farmers make at interview when explaining their use of their selected technological configurations. This will include statements regarding farmers' 'mindsets'. For the purposes of this thesis, 'mindsets' will incorporate the personal 'cognitive' rulesets of farmers and their labour resources (i.e. their beliefs, experience and knowledge, including 'tacit' knowledge associated with the use of technologies, Cowan et al 2000; see 3.3.3); their 'normative' rulesets (values, norms etc); and how these relate to their knowledge of the broader 'regulative' rulesets imposed by buyers and agencies (e.g. production and product standards etc) (Geels 2004, p.905; 3.4.1). Such mindsets will therefore include farmers' beliefs about the 'right' way to farm, both in terms of what farmers believe to be desirable and what they believe to be possible, as well as

the ways in which farmers think and feel about the regulative framework within which they operate (e.g. whether they believe that framework to be 'fair').²⁶

As outlined above, buyers' technological frames can be inferred from buyers' demands, expressed through contracts, price setting or other relations with farmers. The analysis will regard these as a proxy for the goals that buyers are aiming to direct progress towards.

4.3 Selecting a Timeframe for the Analysis

An evolutionary perspective – by definition – eschews 'starting points' and 'end points', viewing progress instead as 'ongoing'. However, for practical purposes, it is necessary to select a timeframe for any study. The abolition of the Milk Marketing Board (MMB) in 1994 serves as a useful starting point, as a potentially significant episode within the history of the UK dairy farming sector (see **Chapter 2**) in which institutional changes signalled an expanded role for certain actors (chiefly processors and supermarkets) within the UK value chain for milk. The bulk of the fieldwork for the study was conducted in the summer of 2016, meaning that the study will cover the period 1994-2016 (albeit the overviews of dairy farming technologies and of governance conditions within the value chain for milk, in **Chapter 5**, will contextualise the systems and technologies that were available to farmers from 1994 onwards, and the institutional background within which they have operated).

²⁶ 'Frames' – being constrained by current technological configurations – incorporate both an aspirational element (i.e. "*what problem **should** technology solve? Why and how?*"), and a pragmatic element (i.e. "*what problems **can** [current] technology solve?*"). The former incorporates actors' beliefs about the purpose of technology. The latter incorporates actors' beliefs about the limits of technology. The two are not mutually exclusive. Technological artefacts and configurations, through their use, may condition actors' "visions on 'how to do things'" or of "the best way forward" (Dosi et al 2006, p.1114; Berkhout et al 2003, p.14).

Chapter 5: Populating the Framework

This study will examine socio-technical system reproduction in UK dairy farms. As outlined earlier, “regimes exist across different empirical scales ... [and] there is a need carefully to distinguish in any given context between what constitutes the ‘nested’ and the ‘spanning’ regime, and to be precise in the empirical application of the concept” (Smith et al 2005, p.1493; 3.3.2). It is suggested that socio-technical *systems* also exist across different empirical scales, not least because socio-technical systems and regimes “co-structure each other” (Geels and Kemp 2007, p.442; see 3.3.7).

With that in mind, this study will regard UK dairy farms as socio-technical systems, ‘nested’ within a broader ‘spanning’ socio-technical system (namely, the UK value chain for liquid milk) and its underlying socio-technical regime. The distinction between these different levels of analysis is useful, for the purposes of this study, as it enables the analyst to identify a sector-level technological trajectory for UK dairy farming (i.e. at this high level of aggregation all dairy farms will share common technological characteristics, involving some combination of livestock, feed, and housing technologies, aimed at achieving a broadly shared ‘goal’ at the sector level; see further 5.1) while also allowing the analyst to distinguish, at a lower level of aggregation, differences in the ways in which these common technological inputs are deployed towards the achievement of distinct outcomes and goals at the farm level. This approach enables the identification of different ‘clusters’ of farms at the sub-sector level, allowing the analyst to capture and examine differences in the response of these clusters to similar buyer demands (i.e. whereas a sector level of analysis might assume or conclude that rules developed and enforced by buyers will have similar effects upon all of the farms supplying them, a farm level of analysis may reveal evidence that these rules in fact influence different farms in different ways).

The study will therefore identify and characterise patterns of change within and between clusters of “possible technological directions” in the broader, sector-level technological trajectory for UK dairy farming (Dosi 1982, p.154; 4.1 - 4.2), which encapsulate farms’ progress towards ‘system goals’. The influence of buyer power upon these patterns of change will be ascertained by considering *whether, how* and *why* farms’ system goals correspond with buyers’ demands.

In order to determine *whether* buyers have influenced individual farms, one must first define the technological trajectory for UK dairy farming and characterise the various clusters of technological directions within it, and identify and characterise change at the farm level within and between these clusters. This involves enumerating the various technological and non-technological components involved in dairy farming that will be regarded as 'relevant' to the analysis, as well as the dimensions along which these components (and their associated outputs) may vary (5.1). Different clusters – 'intensive', 'intermediate' and 'extensive' – will be characterised by different configurations of components and by variations across these dimensions (i.e. these correspond to the diverse 'trade-offs' that may be made between various system components; Dosi 1982, p.148; 4.2). Further, different trade-offs will result in different outputs (i.e. in this way, intensive, intermediate and extensive clusters will each progress towards different system goals at the farm level).

As well as understanding the diversity of system goals that different clusters are moving towards, determining *how* and *why* buyers influence farms' movement within and between clusters also requires a consideration of the diversity of governance conditions within the value chain and the diversity of mechanisms through which buyers exercise power in order to encourage compliance with their demands. Just as dairy farming must be viewed at different levels of aggregation – from high (trajectory), to medium (cluster), to low (farm) – so too must the value chain.

The chapter will therefore provide an overview of the value chain, the actors within it, and its broad conditions of governance (5.2). It will, further, delineate value chains nested within this broader value chain – specifically 'aligned' and 'non-aligned' value chains – which will form the subject of this study. Significant distinctions in the governance conditions within these value chains will also be explained. This will entail:

- Characterising buyers' demands in terms of the security of supply, product characteristics and production characteristics, and enumerating the specific conditions within which, and mechanisms through which, buyers exercise power to encourage compliance with these demands, namely:
 - The depth and pervasiveness of rules (which may vary from cluster to cluster as similar rules may influence different clusters to varying degrees)
 - The separation of powers
 - The categories of sanctions that buyers utilise
 - Indicators of trust within value chains.

- Defining, more broadly, the ways in which actors (both farmers and buyers) frame the ‘meanings’ of dairy farming technologies and the ‘problems’ and ‘solutions’ towards which dairy farming should be directed. Because the influence of buyers will be understood by reference to goals, and examined by reference to the process of frame stabilisation and closure, it is necessary to define a broader arena within which this stabilisation and closure is staged (i.e. broad common dimensions along which different actors’ goals will be defined).

Outputs from this chapter will serve to inform the data needs summarised in **Chapter 6**.

5.1 Dairy Farms as Socio-technical Systems

This section defines the technological trajectory for UK dairy farming for the period covered by the study (1994-2016). This technological trajectory is nested within the broader socio-technical system of the UK value chain for liquid milk and its underlying socio-technical regime, and is therefore defined by reference to the broad social ‘problem’ that dairy farming at the sector level was aimed at solving during the study period. This section will summarise technological and non-technological components²⁷ that are common to farms within this trajectory, before distinguishing the various clusters of technological directions within this technological trajectory (“whose outer boundaries are defined by” the regime; Dosi 1982, p.154) by reference to variations in configurations and/or the utilisation of these components.

For the purposes of this study ‘the provision of food at scale’ will be regarded as the broad social problem that dairy farming is directed towards solving.²⁸ At the sector level, the approach taken towards solving this social problem can be summarised as:

The domestication of dairy cattle for the production of milk to conventional (i.e. not organic) standards by (and as a primary commercial activity of) organised agricultural enterprises, for purchase by milk processors.

²⁷ As discussed already (see 3.3.2, and **Chapter 4**) it is desirable to “differentiate more from less important links and interdependencies” when developing an analytical framework (Millstone 2010, p.294). When taking this approach, it is therefore necessary to privilege certain components within the analysis (e.g. given that this study is aimed at understanding the influence of buyer power upon technological changes, technologies and actors are given greater prominence in the analysis) at the expense of others (e.g. labour and environmental factors are included in the framework, although they are, relatively speaking, placed in the background). This should not serve to diminish the importance of environmental, labour, or financial components to answering other, related research questions.

²⁸ Supporting the rural economy, the preservation of farming traditions, lifestyles, knowledge, and a host of other possible social problems, will be regarded as ‘peripheral’ issues (the use of the term ‘peripheral’ is not intended to diminish the importance of these issues, merely to highlight that they are not the central concern of the *present* study, although, at the farm level of analysis, individual farmers may ‘frame’ the problems and solutions of dairy farming by reference to such issues (see below 5.2).

This study therefore regards dairy farming as a highly-specialised, commercial agricultural activity. It will be noted that the tendency towards increased farm size and consolidation in the UK dairy sector outlined in **Chapter 2** accompanied a long run trend towards greater specialisation within agriculture generally (e.g. Bieleman 2005; Grant 1998), as well the emergence of greater integration and consolidation within in the broader supply chain, enabled by advances in transportation and cold-chain technologies (Nimmo 2011, Grant 1998; Dewick and Foster 2011).

Small scale, subsistence and other non-commercial farming enterprises will be excluded from the analysis, as will farms that process and/or market their milk direct to the consumer.²⁹ Finally, the study excludes farms that produce milk to organic standards.³⁰

5.1.1 Summary of Dairy Farming Socio-technical System Components

This section summarises the categories of components – technologies, actors, institutions and resources – used within the technological trajectory for UK dairy farming, as defined above. The boundaries between these component categories will be regarded as being ‘soft’. For example, although technology may comprise ‘pure information’ (such as ‘codified’ information, residing, for example, in written operating manuals, textbooks, procedures or processes; Cowan et al 2000) some forms of information will also be regarded as ‘resources’ (i.e. labour, knowledge or skills), residing (partially or exclusively) in ‘actors’, often in the form of either ‘tacit knowledge’ (Cowan et al 2000) or ‘beliefs’ (i.e. “cognitive rules”, a subcategory of institutions; Geels 2004a, p.904-5).

Technologies – The study will adopt a broad definition of ‘technology’ in line with the one suggested by Arthur, namely: “[methods] to carry through any given economic purpose ... [which] may exist as pure method or pure information; or may be embodied in physical plant or machinery” (Arthur 1994, p.15). The study will therefore consider both technological ‘hardware’ and ‘software’ associated with dairy farming (David 1985, p.334).

At its simplest, dairy farming involves the conversion by cows of feed inputs into milk. At a minimum, this requires a means of impregnating cows; a space in which to keep (and, optionally, house) these cows; a means of feeding them; a means of harvesting the resulting milk; and a systematic approach to repeating and sustaining this sequence of events as milk

²⁹ Which can be regarded as a ‘niche’ activity, external to the mainstream regime.

³⁰ This study does not regard organic farming (for the production of milk sold to milk processors) as a niche activity, but rather as a subset of the mainstream regime, being subject to broadly the same regime rules that govern conventional farming, in addition to some further (organic) production standards. Because organic farms and conventional farms are therefore governed by different institutional conditions (and for the sake of simplicity) organic producers will be excluded from the analysis.

yields decline after calving. It also requires a means of ensuring the health and welfare of the animals, and of managing their waste products. To enable a more fine-grained analysis of how technological components interact, the technologies associated with dairy farming will therefore be sub-divided into those associated with:

- Feeding
- Buildings and Housing
- Breeding
- Fertility
- Milking
- Animal husbandry and veterinary medicine
- Production cycle ('calving pattern')
- Waste management

The dimensions of variability and change in these technologies will be discussed further in **5.1.2**, below, and form the main distinguishing factor between different clusters of farm socio-technical systems.

Actors – A range of actors are involved in the value chain for liquid milk, including consumers; legislative, executive and judicial authorities; extension agencies and technological input suppliers. However, given that this study is focused on the influence of buyers upon farmers, it will confine its attention to farmers, processors and supermarkets.

Institutions – For the purposes of this thesis I will assume that institutions may include “societal norms, technology standards, regulations, user practices, culture, collective expectations etc” (Markhard and Hoffman, 2016 p.64). Because this study is interested in the effects of buyer power upon farms’ development, it will restrict its scope to private as opposed to public standards (Kaplinsky 2010), i.e. those mandated within contracts for the sale of milk between milk buyers and farmers, in particular where such standards impose requirements that are more detailed or stringent than those stipulated by industry-wide laws, regulations, standards or best practice guidelines developed, implemented and enforced by public bodies (see below, **5.2.6**). In addition to ‘formal’ institutions (i.e. contracts), it will also consider the role of less formal institutions, such as unwritten agreements or relations between buyers and farmers, as well as farmers’ ‘mindsets’, which incorporate ‘beliefs’, or ‘cognitive rules’, underpinning their selected technological configurations.

It will be clear that buyers will typically exercise their power through the medium of institutions (i.e. the ‘rules’ of the game). Therefore, the institutional context may vary

considerably from farm to farm, depending on the buyer and the contractual relationship. The diversity of governance conditions within the value chain is considered in **Section 5.2**, below, which identifies two distinct value chains (aligned and non-aligned) within the broader UK value chain for liquid milk, which will form the subject of the analysis.

Resources will include:

- Labour
- Knowledge / skills embedded in farmers and their labour force (see **4.1**)
- Financial capital
- Land and physical location
- Local climate
- Transport infrastructure and links.

5.1.2 Dimensions of Variability / Change in Technological Components: Defining Clusters

This section details the dimensions of variability and change in technological components and their associated system outputs (i.e. technological trade offs; Dosi 1982, p.148) that serve to distinguish different clusters of possible technological directions within the broader technological trajectory for UK dairy farming, which tend towards distinct system goals.

The analysis will not consider *all* of these components, or all of their interactions, for every farm. Instead, it will focus upon those components and interactions that most usefully illustrate and explain observed patterns of change within each case study. These may vary from case to case, although the processes and mechanisms underlying these components and their interactions may exhibit greater consistency across cases. A summary of the relevant dimensions along which these technological components may vary, along with a (non-exhaustive) list of some potential effects of variations along these dimensions, is included in **Table 5a**.

Table 5a: Dimensions of Variability in Technological Components

Category of Technological Component	Dimension of Variability	Description of Change	Potential Effect(s)
Feeding ³¹	Source	Home grown / grazed	Reduce feed input costs
		Purchased	Increase feed input costs
	Volume	Increase	Increase milk yields.
		Decrease	Decrease milk yields.
		Tailored	Increase milk yields
	Composition/ balance ³²	Increase sugar and starch relative to fibre	Increase milk yields. Reduce constituent content of milk (% butterfat and protein). Increase risk of acidosis
		Increase fibre relative to sugar and starch	Reduce feed intake. Reduce milk yields. Increase butterfat content of milk.
	Frequency	Continuous	Increase milk yields
		Discontinuous	Decrease milk yields
	Method	Feed to yield	"Allocating concentrates on a daily or weekly basis according to yield ... Feeding to yield tends to result in lactation curves with a higher peak yield but more rapid decline as cows respond positively to the challenge of more generous early lactation feeding and negatively to the progressive restriction of allocations in mid to late lactation" (DairyCo 2012b, p.6:13)
		Challenge Feeding	"A system of feeding dairy cows which provides more feed than is justified by the level of the individual cow's milk production. In the early part of the lactation the cow is challenged to produce more milk and in many instances does so. If the cow does not respond the level of feeding is reduced. Called also lead feeding because the cow is led to produce more heavily." ³³
		Flat rate	"Completely opposite to feeding to yield, flat rate feeding involves providing all cows with the same quantity of concentrates each day throughout the lactation" (DairyCo 2012b, p.6:14)
		Step	"Provides a convenient half-way house between feeding to yield and flat rate feeding, more closely meeting cows' nutritional needs at each stage in the lactation, while maintaining as much simplicity as possible." (DairyCo 2012b, p.6:14.)
		Self / easy feed	Self / easy feed systems "allow machinery and labour costs to be kept to a minimum, although they are poorly suited to high output regimes" (DairyCo 2012b p.3:6)
		Cut and cart	Allows "higher daily dry matter intakes to be achieved than self-feeding" but with higher associated labour and machinery costs (albeit lower than TMR, see below; DairyCo 2012b p.3:6).
		Total mixed ration (TMR)	TMR approaches involve higher machinery and labour costs than other systems, but offer greater flexibility and the potential "to maximise dry matter intakes and optimise rumen fermentation" (DairyCo 2012b p.3:7). However, "the main nutritional disadvantage is that individual cows can become too fat if they eat large amounts of the TMR and don't milk as well as they should" (Chamberlain and Wilkinson 1996, p126)
	Form	Increase particle size	Reduce feed intake (and milk yield).
		Reduce particle size	Increase feed intake (and milk yield) at risk of acidosis (DairyCo 2012b, 2:7)

³¹ DairyCo 2012b, Chamberlain and Wilkinson 1996; see further **Appendix 5A** for varieties of concentrate feeds

³² Acidosis is a metabolic condition in cattle resulting from "feeding excessive amounts of non-structural carbohydrates and highly fermentable forages, and insufficient dietary coarse fibre", Plaizier et al 2009 p.21

³³ <https://medical-dictionary.thefreedictionary.com/challenge+feeding>

Table 5a: Dimensions of Variability in Technological Components (Continued)

Category of Technological Component	Dimension of Variability	Description of Change	Potential Effect(s)
Buildings and housing ³⁴	Type	Cubicle	Increase fixed costs relative to 'loose yards'. Reduced ongoing bedding costs and permit a higher stocking rate, but incur higher fixed (upfront) costs and may result in increased lameness and knee/hof damage compared with straw yards. (DairyCo 2012c, p.14-15).
		Yard	Potentially higher bedding costs Lower incidence of lameness but increased mastitis levels when compared with cubicles. DairyCo 2012c, p.14-15).
	Duration	Increase	Permit greater control of diet and monitoring of cows. Increase need to manage waste.
		Reduce	Permit greater access to grazed grass. Reduce need to manage waste.
Breeding & genetics ³⁵	Breed	Ayrshire	Improved forage conversion (reduced purchased feed) and increased longevity
		Brown Swiss	Improved forage conversion (reduced purchased feed) and animal health.
		Crossbreed	Hybrid vigour ³⁶ "is the tendency of a crossbred animal to have qualities superior to that of either parent but not more than the dominant breed."
		Friesian	Reduced vet costs. Dual purpose (beef and milk)
		Guernsey	Increased constituent content of milk (butterfat and protein)
		Holstein	Increased yield. Susceptible to reduced fertility and lower survival (Dillon et al 2006)
		Jersey	Increased constituent content of milk (butterfat and protein). Improved calving ease.
		Montbeliarde	Increased protein content in milk. Reduced cell counts in milk.
		Norwegian Red	High production, health and longevity
		Shorthorn	Improved milk quality (constituents) and forage conversion.
	Breeding strategy (use of genetic indices)	Selection for production	
		Selection for fertility	
		Selection for lifespan	
		Selection for maintenance	
		Selection for SCC	
		Selection for udder	
		Selection for feet and legs	
		Selection for calving ease	
	Replacement planning ³⁷	Home-rear	Reduce risk of disease transmission. Increase need to maintain tight calving window (i.e. fertility)
		'Flying herd'	Increase risk of disease transmission. Reduce need to maintain tight calving window (i.e. fertility)
Milking	Method	Herringbone	"financially advisable for herds of up to 350 cows" (O'Brien et al 2006, p.6)
		Rotary	High capital costs, but increased efficiency for herds above 350 (O'Brien et al 2006, p.6)
		Robot	Reduce labour costs. High upfront fixed costs and ongoing maintenance costs.
	Frequency	Increase	Increase overall milk output. Increase labour costs (unless robots used)
		Decrease	Reduce overall milk output. Reduce labour costs

³⁴ DairyCo 2012c

³⁵ <https://dairy.ahdb.org.uk/technical-information/breeding-genetics/£pli/>; see further **Appendices 5B** and **5C** for production and other characteristics of the main breeds of dairy cow

³⁶ http://www.dairyco.org.uk/technical-information/breeding-genetics/crossbreeding/#.U6wbsKX_ZBU

³⁷ <http://dairy.ahdb.org.uk/technical-information/business-management/planning-ahead/short-term/replacements/#.Vp4ylhGrbzI>

Table 5a: Dimensions of Variability in Technological Components (Continued)

Category of Technological Component	Dimension of Variability	Description of Change	Potential Effect(s)
Animal husbandry and Veterinary Medicine			Dairy cattle are susceptible to a range of medical conditions, including mastitis, tuberculosis (TB), lameness and impaired mobility, bovine viral diarrhoea (BVD), Johnes Disease, and more. ³⁸ These may be aggravated or alleviated by variations in housing conditions, feeding practices, milking frequency and protocols, or breeding decisions; as well as by differences in approaches to dry cow therapy and the use of antibiotics. Although a full consideration of these conditions and their treatments is beyond the scope of this study, it is sufficient to note that animal husbandry and veterinary medicine technologies will be strongly influence by prevailing feeding, housing, breeding and milking technologies.
Fertility			Methods of improving fertility and the detection of 'heat' include: crossbreeding, oestrous synchronisation, activity monitors, and tailpainting.
Production cycle / Calving pattern	Spring calving		Results in peak yields in the Spring, due to 'lactation curve' ³⁹
	Autumn calving		Results in peak yields in the Autumn, due to 'lactation curve'
	All year calving		Results in a level annual production profile as lactation curves of cows overlap
Waste Management	Storage and disposal		Requirement for waste management increases as period that cattle are housed increases, and with increased feed intake.

³⁸ <https://dairy.ahdb.org.uk/technical-information/animal-health-welfare/>

³⁹ The lactation curve of a dairy cow describes the "peak or maximum daily yield occurring between 4 and 8 weeks after calving, followed by a daily decrease in milk yield until the cow is dried off" Silvestre et al 2009 p.308

Given the vast number of possible configurations of these technological inputs, the numerous different ways in which these may be deployed, and the diversity of resulting system outputs, it is desirable to reduce these to a smaller number of clusters or stylised system ‘types’, characterised by the different possible combinations of technologies and the range of possible trade offs between them. For the purposes of this study, the following clusters will be used:

- ‘**Intensive**’ farms, which are characterised by a high intensity of technological inputs and outputs per unit of livestock, land and/or labour relative to sector averages.
- ‘**Extensive**’ farms, which are characterised by a low intensity of technological inputs and outputs per unit of livestock, land and/or labour relative to sector averages.
- ‘**Intermediate**’ farms, which occupy a position between the above extremes.

As should be clear, the main distinction between these clusters is the intensity of technological inputs and associated outputs. These clusters are considered in greater detail in **Table 5b**, and may be compared with similar categories developed by the National Farmers Union (NFU) in 2010 and by DairyCo in 2012 (see **Boxes 5a** and **5b**). The different inputs and outputs associated with these clusters will serve as a proxy for ‘system goals’ (4.2), nested within the broader regime level goal defined above (see further 5.2.5), and these clusters will tend towards distinct system goals.

Broadly, observed patterns of technological change may be characterised as either change *within* these clusters (e.g. further intensification of an already intensive farm) or as change *between* clusters (e.g. change from the intermediate to the extensive cluster).

Significantly, because the dimensions of change outlined above frequently involve changes of scale rather than kind (in particular changes such as housing period, and feed inputs):

- The boundaries between these clusters may be indistinct. Broadly, changes of scale may typically be indicative of change *within* a cluster rather than change between clusters. However, ‘thresholds’ between clusters will exist, meaning that a change of scale above such a threshold may constitute a change between clusters;
- ‘High’ or ‘low’ intensity of inputs will mean ‘high’ or ‘low’ relative to the mean input intensity of the rest of the population or sample.

That being said, there will be some specific technological artefacts or processes that are used predominantly or exclusively within intensive, intermediate and extensive farms. For example,

feeding a 'total mixed ration' and milking three times a day will typically be associated with 'intensive' production models as the aim of such technologies is to maximise system inputs and outputs per cow.

Box 5a: NFU Farm Categories

In 2010 the NFU proposed three main producer types in Great Britain, as follows:

- "Extensively grazed systems" in which "the cows spend the majority of the year outdoors and are likely be out wintered in all weather conditions"
- "Grass based" systems in which cows "graze during the spring and summer months, and [are] housed for up to six months of the year, usually from late autumn through to the end of winter, when the weather is wet and cold and grass stops growing"
- "Zero grazed" systems, in which herds "spend the majority of their time indoors in modern, well ventilated and light cattle sheds".

Source: <http://www.thedairysite.com/articles/2549/dairy-farming-systems-in-great-britain>

Box 5b: DairyCo Farm Categories

In 2012, DairyCo identified three main producer approaches (DairyCo 2012a, p.4):

- Cows at grass: "Predominantly grass-based and operating at lower yield levels".
- Composite: "Maximum use of family labour and a mixed approach to feeding and housing".
- High-output cows: "Generally housed with intensive use of major inputs".

These categories were constructed according to "the most important ways in which dairy enterprises differ", which DairyCo defines as (DairyCo 2012a, p.5):

- The feeding strategy adopted
- Intensity of input use
- Type of output.

Table 5b: Characteristics of Clusters

TECHNOLOGICAL COMPONENT CATEGORY	CHARACTERISTICS OF CLUSTER		
	INTENSIVE	INTERMEDIATE	EXTENSIVE
FEEDING	Farms are likely to make minimal use of grazed grass as a feed input. Feed rations likely to be based around energy dense feeds, which may be tailored precisely to the cows' energy requirements and fed as a "total mixed ration".	Feeding approaches may seek a balance between maximising yields (cf. intensive farms) or minimising feed costs (cf. extensive farms), and may be more influenced by other factors such as, for example, labour costs.	Farms are likely to graze more extensively than other systems, using relatively lower amounts of purchased and concentrate feeds per cow.
BUILDINGS AND HOUSING	Cows may be housed for long periods of the year (potentially all year round) due to a desire to precisely control feed, and due to the relative fragility of the livestock (see below).	Cows are likely to be housed approximately half of the year and kept outdoors for the remainder.	Cows are likely to be housed for as short a period as possible, within the limits of the local climate, in order to maximise their access to grazed grass.
BREEDING	Holstein cows are likely to be preferred, in particular pedigree Holsteins that are genetically selected for their ability to produce high volumes of milk (albeit with relatively lower proportions of protein and butterfat). These cattle are generally less resilient and may suffer from lower fertility compared with other breeds (see below and Appendix 5C).	Farmers may place less emphasis on genetic selection for maximum production and greater attention on other traits (see Table 5a).	Breeds are likely to be selected that can withstand the shorter housing period and lower feed inputs associated with extensive grazing.
MILKING	Intensive systems are more likely than other systems to milk three times per day due to high output of the cows and the fact that the cows spend more of their time indoors (i.e. near the milking parlour). Where focused on maximising output per unit of labour, automated "rotary" parlours, or milking robots may be preferred.	Cows are likely to be milked twice a day.	Cows are likely to be milked twice a day.
ANIMAL HUSBANDRY AND VETERINARY MEDICINE	Stocking densities may be higher than less-intensive operations due to the minimal use of grazed grass. This, combined with intensive housing, may increase the risk of disease transmission and of conditions such as lameness and mastitis, which may be exacerbated by the selection of breed and the physiological pressures placed on high-yielding cows (Dillon et al 2006).	No particular distinctions may be observed between intermediate farms and extensive or intensive farms	Long periods of grazing may raise health and welfare issues.
FERTILITY	Such systems may experience challenges with fertility, owing to the characteristics of the "high yielding cow" (Dillon et al 2006)	No particular distinctions may be expected with regards to fertility n/a	
PRODUCTION CYCLE	Year round calving models may be preferred and enabled because the lack of reliance upon grazed grass reduces exposure to seasonal variations in grass growth.	No particular distinctions may be expected between intermediate farms and extensive or intensive farms	Such models may be expected to adopt a Spring calving model, meaning that the cows' maximum energy requirements coincide with the strongest grass growth

5.2 The Value Chain for Milk: An Overview

The value chain for milk can be studied at various levels of analysis. At the macro-level, milk and dairy products are traded on global markets and there is, therefore, a truly *global* value chain for milk. At the meso-level, separate value chains may be distinguished by reference to geography, jurisdiction (i.e. regional or national value chains) and/or product category (i.e. liquid milk, cheese, butter, powdered products etc). At the micro-level, these value chains may be further distinguished by reference to their 'lead firms' and/or related distinctions in their governance conditions (Kaplinsky and Morris 2001, p.8). This section describes the governance conditions within the UK value chain for liquid milk. In doing so, it explains:

- Why this study will focus upon the *UK* value chain for *liquid* milk as opposed to viewing the value chain at a higher level of aggregation (e.g. as a global value chain, or the value chain for all dairy products)
- Governance conditions across the UK value chain for liquid milk, and distinctions at more micro-levels of analysis (i.e. distinctions between 'aligned' and 'non-aligned' value chains nested within the broader UK value chain for liquid milk, see below) that are significant for the purposes of this analysis.

5.2.1 Subsector Heterogeneity in Production and Product Characteristics

The UK value chain for milk has been described as "relatively simple" (Mylan et al 2015, p.24). This perhaps overlooks the fact that there are many possible approaches to dairy farming in the UK (detailed above; 5.1) with different *production characteristics*. Although these all involve some combination of land, cattle, feed, and milking technologies, there is a range of different possible configurations of technological and resource inputs (see 5.2), a multiplicity of actors (with different goals), and a diverse institutional background (5.2.5).

Moreover, although various farming approaches result in a broadly homogenous product (i.e. raw milk), there is nevertheless a degree of variability within that end product (e.g. in terms of milk quality and constituent content). At one extreme, some farms produce 'white water'⁴⁰ (large volumes of milk per cow, with a low butterfat and low protein content, typically associated with the use of high-yielding Holstein cattle that are fed energy-dense diets). At the other extreme, some farms will produce smaller volumes of milk containing proportionally more butterfat and protein (typically resulting from more grass-based diets and often the use of breeds such as the Jersey or Guernsey). Similarly, there is a range of contracts for the sale of milk, containing incentives or penalties to encourage the production of milk that conforms

⁴⁰ <https://dairy.ahdb.org.uk/technical-information/business-management/accounts/outputs-money-which-earns/milk/>

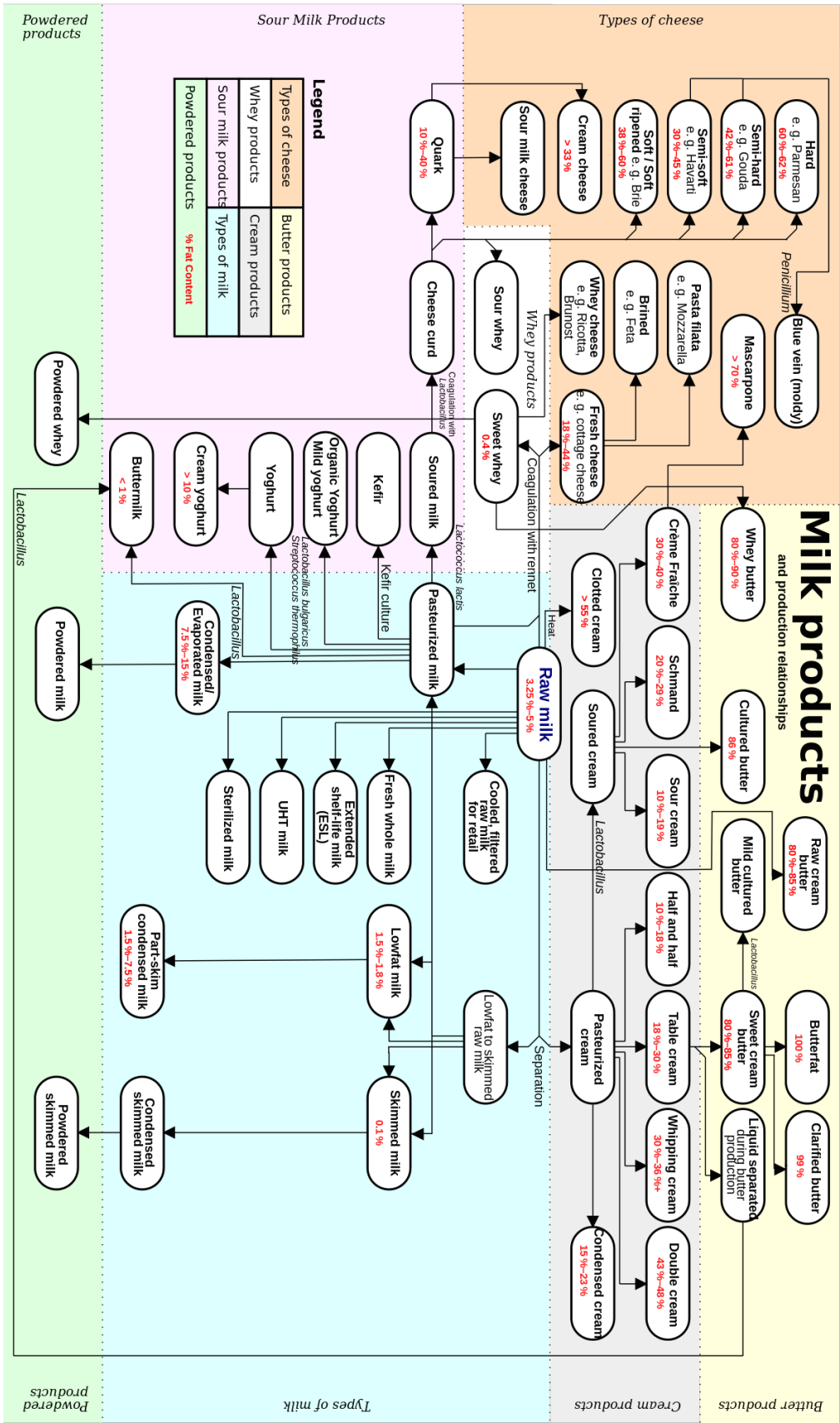
different *product characteristics* (in terms of e.g. volume, constituent content, and/or somatic cell count⁴¹; see further 5.2.5).

It follows that the raw milk delivered from farms may be put to a range of uses. Beyond the farm gate, raw milk is directed towards one of two broad market segments: ‘liquid milk’ (i.e. for drinking) and ‘manufacturing’ (DairyCo 2013b, p.15). However, these segments are further subdivided into a wide array of final products (see **Figure 5a**). These end products may be intimately connected, both in terms of their production process and their markets. For example, excess butterfat removed in the processing of milk for the liquid market forms the basis of cream and butter production (DairyCo 2011a, p.9). Increased demand for drinking milk would result in a surplus of butter and cream in the absence of a commensurate increase in demand for those products, resulting in price depression in those markets. Conversely, increased demand for cream and/or butter may result in increased production of liquid milk, but in the absence of increased consumer demand for drinking milk, this may ultimately serve to depress farmgate prices. Such effects have been observed as a result of changing UK consumer preferences away from ‘full cream’ drinking milk and towards ‘semi-skimmed’ milk (Public Health England 2014).

Similarly, given the broad range of possible by-products from the manufacture of cheese (see **Figure 5a**), price movements within any of these end markets may influence production patterns and returns further upstream. Such interconnectedness has led many to argue that, ultimately, *domestic* farmgate prices for milk are determined by *global* commodity market prices (House of Commons 2011, p.12).

⁴¹ NB: although industry bodies might argue that farmers often fail to match their production approach to the terms of their contract (i.e. some farmers produce white water when their contracts reward the production of constituents). Personal communication, DairyCo representative 2 December 2014

Figure 5a: Milk Products and Production Relationships



Source: Milch.svg: The original uploader was WikiNight at German Wikipedia (later version(s) were uploaded by Andreas 06. Dapete, Gyrolux at de.wikipedia. (Original text: Übersicht selbst erstellt) Milkproducts.svg: Pschemperivative work: Kbh3rd (talk) - Milch.svg Milkproducts.svg, GFDL, <https://commons.wikimedia.org/w/index.php?curid=9879413>. NB: Although this figure relates to the German milk value chain the products and product relationships are nevertheless relevant to the UK and global value chain, as an illustration of the complexity of those chains.

Adding to this complexity, the end products in **Figure 5a** have widely different characteristics. This has implications for processors and retailers operating in these markets. Products may differ according to, for example (the list is not exhaustive):

- Consumer demand (e.g. whereas the UK is self sufficient in liquid milk there is a trade deficit – and exposure to international markets – in cheese, butter and yoghurt; House of Commons 2011, p.10)
- Elasticities of demand – some products will be regarded as ‘staples’, others as ‘luxuries’
- Value added – Some milk products will command more of a premium than others, depending upon such factors as the production process, their provenance, consumer trends etc.
- Shelf life – liquid milk is perishable, whereas other dairy products may be stored for longer periods.
- Transportation costs
- Processing costs and capacity.

These (and other) factors may influence actors’ strategies at each link in the value chain, resulting in impacts both upstream and downstream.

5.2.2 Processors, Market Concentration and Value Chains Nested within the UK Value Chain for Liquid Milk

In many ways, processors (often referred to as ‘dairies’) act as ‘gatekeepers’ to the sector.⁴² In spite of the broad range of end markets outlined above, the vast majority of milk in the UK will pass through one of a small number of processors. In 2013, of a total of 13,563m litres of milk available for human consumption in the UK, 12,952m litres were delivered to processors (see **Figure 5b**). The processor market is extremely concentrated, with 80% of milk produced in 2011/12 being purchased by just seven processors (DairyCo 2013b, p.4). This concentration is even more pronounced since 2012 following the takeover of the major processor Robert Wiseman by German dairy giant Müller⁴³ and the merger of Arla with Milk Link.⁴⁴

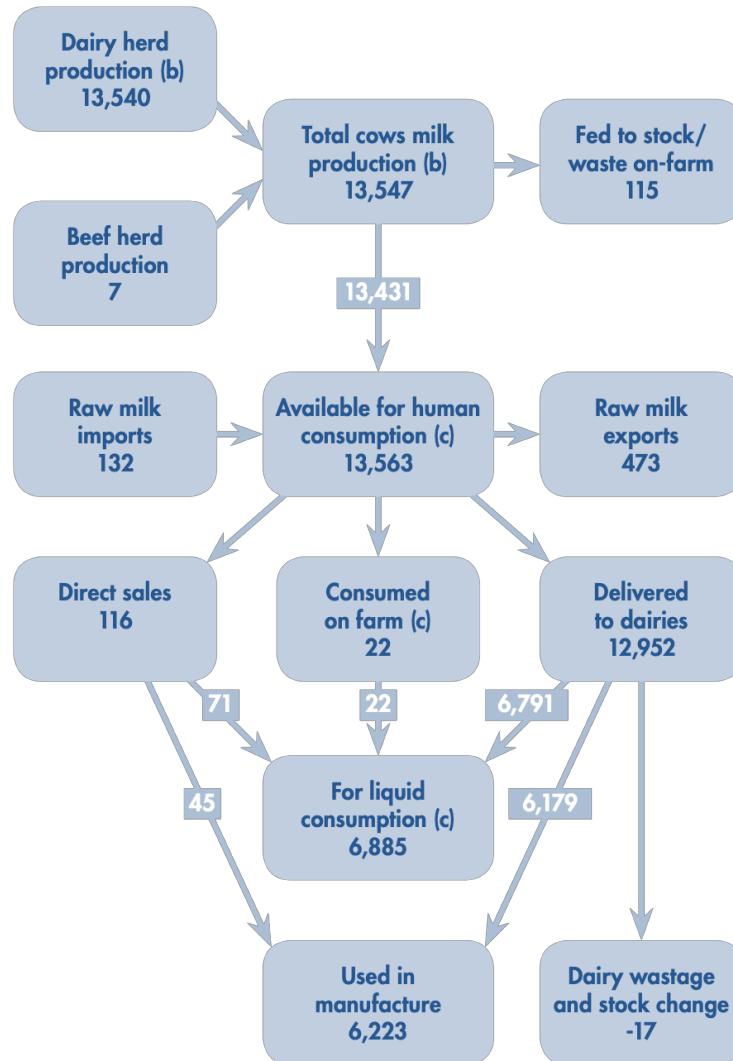
This – in combination with the concentration in the retail market – has implications for value chain governance, including the duration and strength of buyer-supplier relationships, and the terms by which those relationships are governed (see more below, **5.2.6**).

⁴² Personal communication, DairyCo representative 2 December 2014

⁴³ <https://www.bbc.co.uk/news/uk-scotland-scotland-business-16572516>

⁴⁴ <https://www.arlafoods.co.uk/overview/news--press/2012/pressrelease/milk-link-and-arla-foods-amba-farmers-vote-yes-to-merger-proposal-791953/>

Figure 5b: UK Milk Flows 2013 (million litres) (a)



(a) Figures are provisional.

(b) Excludes any suckled milk.

(c) Includes 7 million litres of milk produced by the beef herd.

Note: Totals may not agree due to rounding.

Source: Defra.

Source: DairyCo (2014), p.29

Moreover, given this market concentration, the largest processors will typically serve two or more end product markets (see **Table 5c**). One result of this is that the price received by a farmer supplying milk to domestic liquid markets may be influenced by price movements in any of the global commodities markets (e.g. for cheese, milk powders, or cream and butter) that the processor operates in (e.g. House of Commons 2011, p.13).

Further, processors employ various strategies for managing risks associated with end markets, chiefly, the practice of ‘balancing’ (MDC 2005 p.20). Due to variability in both upstream supply (resulting in part from seasonal fluctuations in production; see 5.1.2) and downstream demand, processors must address inevitable mismatches between the two, and they therefore take a strategic decision to be either a net seller or a net buyer into spot markets for milk (see Table 5c). *Security of supply* is therefore a priority for milk buyers (see further 5.2.5).

One consequence of such practices is that there may be a fundamental dislocation between the on-farm production of milk and the end use to which it is put. Studies suggest that such ‘commodification’ of products dilutes producers’ power and ability to capture value (Kaplinsky and Fitter 2004; of which more below, 5.2.3). Indeed, as Kaplinsky and Morris note: “the way in which producers are connected to final markets may influence their ability to gain from participating in global markets ... participation in global markets is not just governed by trade policies in final market countries ... [but] also reflects the strategic decision of the lead firms in the value chains” (Kaplinsky and Morris 2001, p.12-13).

Table 5c: Estimated distribution of raw milk to market sectors 2011/12⁴⁵

	Aligned liquid milk supply	Liquid milk market	Brokering in liquid milk market	Branded dairy products	Non-branded cheese market	Commodity cheese	Other dairy products (ie cream/butter)	Other commodity processing
Arla Foods	62%	20%	4%	14%			10%	
Caledonian Cheese*				44%	29%			27%
Dairy Crest	17%	61%		25%	2%		3%	
First Milk	3%		42%	6%	34%		15%	
Glanbia Cheese					100%			
Meadow Foods*			50%				50%	
Arla Milk Link		9%	41%	9%	34%		7%	
Müller UK				100%				
Müller Wiseman Dairies	50%	39%		11%				

* Estimated based on 2011/12 production profile – may equal more than 100%.

Source: DairyCo 2013, p. 14

⁴⁵ This table shows a snapshot of the estimated flow of raw milk into different market sectors in the period April 2011 to March 2012. The amount of raw milk going into different sectors continually changes in line with market dynamics and this table is therefore not an accurate reflection of the current marketplace.

Although retailers (i.e. supermarkets) do not serve multiple global markets, they must still take measures to match supply to demand, particularly because demand levels for liquid milk remain fairly constant throughout the year⁴⁶, whereas production is more variable, traditionally peaking in the spring (*security of supply* is therefore a priority for supermarkets as well as processors; see further below, 5.2.5).

One important way in which milk buyers match supply to demand is to implement measures within farmers' contracts, either in the form of bonuses or penalties for production above/below a specified level (see below 5.2.6)

A more thorough examination of the full range UK milk buyer strategies (and of the effects of these upon the prices that buyers are prepared to pay farmers for raw milk, or that they willing to accept from downstream purchasers for processed milk) is beyond the scope of this study. Instead, the discussion above merely serves to highlight the complexity of value chains for milk and dairy products; to emphasise the fact that these value chains are interconnected; and to demonstrate that, rather than there being one "relatively simple" value chain for milk in the UK (Mylan et al 2015, p.24), there are instead several different value chains (at a minimum one for liquid milk and one for manufacturing), which interact with one another.

Indeed, the picture is made still more complex because, within the value chain for liquid milk, there are at least three separate but interrelated value chains, associated with three distinct arrangements for the purchase of liquid milk (and therefore distinct conditions of value chain governance⁴⁷):

- **Non-aligned** – In this arrangement, milk buyers (including the supermarkets Asda and Morrisons, the discounters such as Aldi and Lidl, and the broader 'middle market' including convenience stores, catering companies, coffee shops etc) purchase their milk from a generic pool of farmers supplying a processor. The majority (76%) of milk in the UK is purchased in this way,⁴⁸ including milk destined for processors' branded liquid milk products. Such arrangements introduce the potential for 'dislocation' of producer from end market (outlined above).
- **Aligned, non-segregated** – In this arrangement, supermarkets source their milk from a dedicated pool of producers. The supermarket outsources the collection and processing

⁴⁶ Personal communication, DairyCo representative 2 December 2014

⁴⁷ Personal Communication, DairyCo representative 2 December 2014

⁴⁸ DairyCo 2013b, p.8: "approximately one in every four litres (24%) of milk produced in GB during the 2011/12 milk year was purchased on retailer aligned contracts"

of the milk (the contracts for these functions being put out to tender periodically).

However, the milk is not 'segregated' (or ring-fenced) but is instead pooled with all of the other milk collected by the processor (including the processor's 'non-aligned' pool). During the period covered by this study, The Co-operative was the only supermarket operating this purchasing model.

- **Aligned, segregated** – In this arrangement, supermarkets (namely, Tesco, Sainsbury's, Waitrose, and M&S) source their milk from a dedicated, traceable pool of producers. The supermarket outsources the collection and processing of the milk, which is 'segregated' (i.e. kept separate from the other milk handled by the processor). The issue of 'dislocation' is therefore diminished. Moreover, such segregation may accompany the specification of production or product characteristics distinct from those prevalent across the broader value chain for liquid milk (see 5.2.5), as well as different buyer-farmer relationships and mechanisms of value chain governance, such as benchmarking of farmers against each other (see 5.2.6).

Again, although the aim of this study is to distinguish the influence of different buyers upon farmers, and it is therefore necessary to distinguish these different value chains and their distinct governance conditions for the purposes of analysis, it is difficult to consider the value chains of different buyers completely in isolation, given that processors may operate across all three. For example, a processor operating an aligned milk pool for a supermarket may use milk from farmers that supply its non-aligned pools in order to make up shortfalls to the aligned pool⁴⁹, paying those farmers a bonus to the usual non-aligned price they receive (i.e. a form of 'balancing').

This practice highlights the fact that, because processors operate across both aligned and non-aligned value chains, aligned contracts have in practice served to create a system of 'haves' and 'have nots' (House of Commons 2011, p.14). Indeed, as Kaplinsky and Morris note, "parties are often involved in different value chains and these may result in cross-cutting power between value chains with the demands of one dominating the other with detrimental effects down the chain" (Kaplinsky and Morris 2001 p.66).

Such effects may be understood through a consideration of distributional outcomes and value chain governance, discussed below (5.2.3), which will further illuminate the shortcomings associated with sector-level approaches to analysing buyers' influence upon farmers, supporting the farm-level analytical approach adopted in this study.

⁴⁹ e.g. the Tesco and Asda 'Seasonal' milk pools www.ethicalconsumer.org/ethicalreports/dairy-industry-sector-report/milkpricewars.aspx

Taken in combination with the different clusters outlined in 5.1, above, farms will fall into one of the following six broad categories, for the purposes of this study:

- Aligned intensive
- Aligned intermediate
- Aligned extensive
- Non-aligned intensive
- Non-aligned intermediate
- Non-aligned extensive.

5.2.3 Distributional Outcomes across the Value Chain for Liquid Milk

Bearing in mind the limitations outlined in the preceding section, the following provides a high-level analysis of distributional outcomes within the value chain for liquid milk as a whole (i.e. aligned and non-aligned value chains).

Estimated gross output values for the various activities in the value chain for liquid milk are readily available for dairy farming, processing and retailing, although it is not possible to determine the value captured by upstream suppliers of agricultural inputs (i.e. machinery, feed, consultancy etc).

Up until 2011, DairyCo (now AHDB Dairy) published details of dairy supply chain margins for farmers, processors and retailers in the liquid milk, mild cheddar and mature cheddar markets.⁵⁰ For the year 2010/11, these figures are summarised in **Table 5d**, while **Figure 5c** shows fluctuations in these margins over time – notably a ‘double squeeze’ on processor margins can be seen in 2010 as farmgate prices increased and retail prices dropped simultaneously, with retailers apparently passing losses in revenue on to processors.

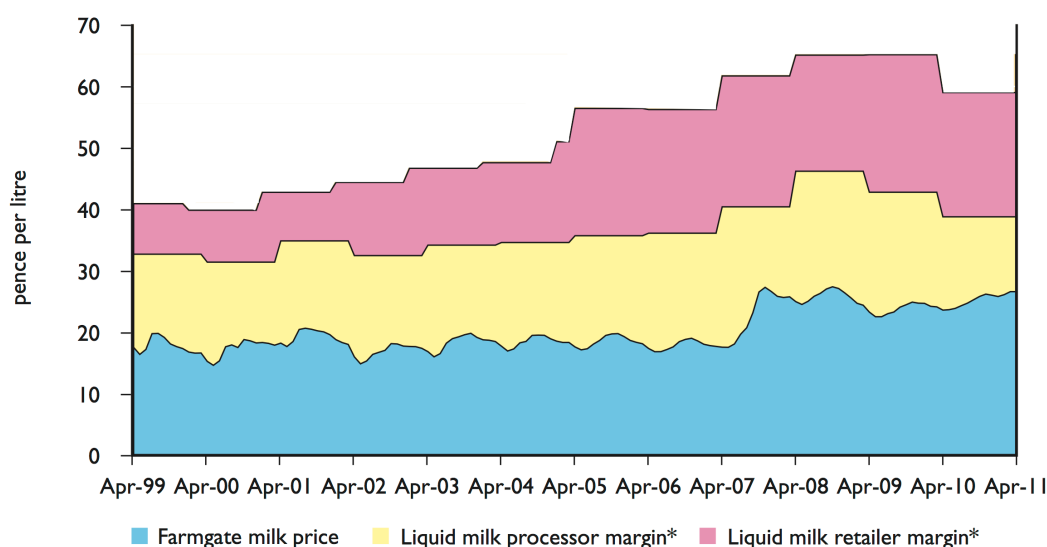
Table 5d: Liquid milk value chain gross margins 2010/11

		Value captured (as % of final retail price)	Value captured (ppl)
Distributional outcomes (value extracted by each actor)	Dairy Farmers	43%	25.327
	Processors	23%	13.547
	Retailers	34%	20.026
TOTAL		100%	58.9p

Source: Adapted from DairyCo 2011b, p.6

⁵⁰ <https://dairy.ahdb.org.uk/market-information/processing-trade/dairy-supply-chain-margins/dairy-supply-chain-margins/#.WdHxexSgf5o>

Figure 5c: Prices and gross margins for UK liquid milk 1999-2011



* Gross margin equals the difference between the selling price and the buying price for milk

Source: DairyCo 2011b, p.6

The gross output values summarised above must be interpreted with some caution, based as they are upon estimated average annual prices paid and received by all chain participants. For example, they do not capture fully:

- **The degree of price variation in the market⁵¹** – Indeed, while the average annual farmgate price for the year 2010/11 was 25.33ppl, the price received under the best paying contract was 29.72ppl compared with 23.79ppl under the worst.
- **The range of prices received by processors from different retailers** – The prices received by processors from retailers may vary according to the nature of the end product (e.g. ‘branded’ liquid milk products versus ‘own label’) and, moreover, the relative bargaining powers of the parties involved. Furthermore, it is unclear what categories of retailers are included in this data, i.e. whether the figures refer exclusively to large supermarket retailers (‘multiples’) or whether the ‘middle market’ (smaller retailers, caterers and food service businesses, etc) is included.
- **The range of final retail prices for liquid milk products** (e.g. branded, own label etc) – Branded products will have a different retail price than supermarkets’ own label

⁵¹ The figures in **Table 5d** are also exclusive of bonuses, when compared against: <https://dairy.ahdb.org.uk/resources-library/market-information/milk-prices-contracts/uk-farmgate-milk-prices/#.WdS1rxSgf5o>

products. For example, at the time of writing a 2 litre bottle of Tesco's own brand semi-skimmed, filtered milk cost £1.30⁵², whereas a 2 litre bottle of Arla Cravendale semi-skimmed, filtered milk cost £1.80.⁵³

Given the observed variability in the above parameters, a range of distributional outcomes is possible, and in particular the difference in distributional outcomes between aligned and non-aligned value chains may be considerable. Although farmers, processors and retailers may *in aggregate terms* capture 43%, 23% and 32% of the value of liquid milk sales respectively, these figures do not illuminate the differences in "*distributional outcomes within any particular link of the chain*" (Kaplinsky and Morris 2001, p.42). It is therefore important to consider not only *inter-link* distributional outcomes but, moreover, *intra-link* distributional outcomes, which suggests not only that these value chains should be analysed separately, but that a farm, rather than a sector, level of analysis may better illuminate buyer influence upon farms.

For example, if one were to consider distributional outcomes for farms on retail-aligned contracts alone, the farmer may capture a relatively larger proportion of value (compared with the sector mean). Moreover, it may be that this comes at the expense of processors' margins, assuming that the retailer is able to pass costs on to the processor (e.g. DairyCo 2011b, p.8). Ultimately, processors may look to offset the reduced margins associated with servicing supermarket contracts by paying a lower farmgate price to their non-aligned suppliers. Indeed, there are concerns within the industry that farmers on non-aligned contracts are effectively subsidising those on aligned contracts.⁵⁴

These disparities between the distributional outcomes for farmers operating in aligned chains, compared with those operating in non-aligned chains, which are exacerbated by the involvement of processors within both chains, therefore have implications for value chain governance, requiring analysis at the sub-sector level.

5.2.4 Profitability and Specialisation: Variability by Cluster

A further shortcoming of analysing distributional outcomes at the sector level, as represented in **Figure 5c**, is that gross margins may not provide an indication of "the incomes which are sustained in different parts of the chain" (Kaplinsky and Morris 2001 p.42) as they don't

⁵² <https://www.tesco.com/groceries/en-GB/products/253737115>

⁵³ <https://www.tesco.com/groceries/en-GB/products/257264875>

⁵⁴ Personal Communication, December 2014

account for the different production costs associated with different farm socio-technical systems (different input costs associated with different clusters of farm systems can be seen in 5.1.2, Tables 5a and 5b, above).

Profits can be obtained by deducting farm production costs, processing costs, and retailing costs from gross margins at each stage in the chain, and may offer a more useful perspective on distributional outcomes. For example, farmers' gross margins for 2010/11 represent 43% (i.e. the majority) of value captured, although when production costs are accounted for farmers on average made a loss of -3.96 pence on each litre of milk sold (and made losses throughout the period from 2006/7 to 2010/11; Table 5e).

Again, sector-level profit margins conceal the considerable variation in production costs from farm to farm. As an extreme example, a farm with low production costs that is on a retail-aligned contract (i.e. receiving a higher farmgate price) may be considerably more profitable than a farm with high production costs on a non-aligned contract. This has implications in terms of the effectiveness of mechanisms of value chain governance in influencing farms. For example, it may be that sanctions imposed by buyers – in the form of a high/low milk price – influence different farm clusters differently, due to differences in the production costs of these clusters.

Table 5e: Liquid milk value chain net margins 2006/7 – 2010/11

	Year				
	2006/7	2007/8	2008/9	2009/10	2010/11
Farmers' gross margin (farmgate price) (ppl)**	17.85	22.85	25.75	23.79	25.14
Farmers' cost of production (ppl)	22.08 ¹	24.59 ¹	26.64 ¹	27.35 ²	29.10 ²
Farmers' profit (ppl)	-4.23	-1.74	-0.89	-3.56	-3.96
Processor selling price**	36.06	40.34	46.10	42.71	38.77
Processors' gross margin (ppl)**	18.21	17.49	20.35	18.91	13.63
Processors' costs**	n/a	n/a	n/a	n/a	n/a
Processors' profit (ppl)**	n/a	n/a	n/a	n/a	n/a
Retailer's selling price**	56.13	61.59	64.26	64.46	58.14
Retailers' gross margin** (ppl)	20.07	21.25	18.17	21.75	19.37
Retailers' costs	n/a	n/a	n/a	n/a	n/a
Retailers' profit (ppl)	n/a	n/a	n/a	n/a	n/a

** adapted from monthly data published by DairyCo. <https://dairy.ahdb.org.uk/resources-library/market-information/processing-trade/dairy-supply-chain-margins/#.WdloFRSg5o> Figures have been annualised for periods starting April to March the following calendar year, and rounded to two decimal places. Figures are prices for liquid milk. 1. Source: Promar International "The real price of milk" <http://milkprices.com/archive/Mar08archive.pdf>; 2. NFU: <https://www.farminguk.com/content/knowledge/COP%20Report%20Feb%202011%20FINAL%202011.pdf>;

Although average farm production costs are readily available – and have been published at irregular intervals by AHDB Dairy, the NFU, and consultants such as Promar International –

there is considerably less transparency surrounding processing and retailing costs. When contacted, the trade association for the British dairy supply chain – DairyUK – was unable (or unwilling) to provide an indication of ‘typical’ processing costs.

The 2010/2011 annual report of Robert Wiseman Dairies⁵⁵ provided a crude means of ascertaining a ‘ballpark’ figure for liquid milk processing costs. The company, prior to its acquisition by Muller, was a large processor operating almost exclusively in the liquid milk market.⁵⁶ Its published operating profit margin therefore corresponded broadly to total revenue from sales of liquid milk minus total (fixed and variable) processing costs for liquid milk (i.e. the company was selected deliberately because of its lack of exposure to markets for other dairy products such as cheese, which will have different processing costs compared with liquid milk).

For the year 2011, the company’s operating profit margin was reported as 4.1% (adjusted for restructuring costs, p.11, p.19), or 4.1p on every £1 of sales. Assuming that the price at which Wiseman sold its milk was in line with the industry average (i.e. 38.77ppl) and its gross margins were in line with industry average (i.e. 13.63ppl) then its profit on each litre sold can be calculated as 4.1% of 38.77ppl (i.e. 1.59ppl), and its processing costs can be calculated as gross margin less profit (i.e.12.04ppl).

Other estimates of variable production costs – including processing (3ppl), bottling (4.5ppl) and distribution (7.2ppl) – suggest that processors’ total variable costs may be in the region of 16.7ppl (2007 prices) (Smith and Thanassoulis 2008, p.20).

There is even less transparency with regard to retailers’ costs, and some disagreement over whether retailers use liquid milk as a ‘loss leader’ (House of Commons 2004). While some within the industry believe that “it could well be that the supermarkets accept no margin on the sales of milk”⁵⁷ it has also been suggested that “there is no evidence that milk is being used as a ‘loss leader’ ...” (Lingard 2015). However, because retailers do not disclose the price at which they purchase milk, or other associated costs, there is no way of proving for certain whether they are using milk as a loss leader or not.

In summary, distributional outcomes in liquid milk value chains are the result of both the relative power of parties and their degrees of specialisation, which vary between aligned and

⁵⁵ <http://www.annualreports.com/HostedData/AnnualReports/PDF/RWD2010.pdf>

⁵⁶ DairyCo 2013b, p.14

⁵⁷ Personal communication with industry insider, 2 December 2014

non-aligned chains. At a general level, farmers are specialised, performing a single function (the production of a generic, commoditised product that can be redirected to any number of end uses), which hinders their ability to secure rents. Processors have diversified their activities, accessing multiple end markets in order to spread risk. Supermarkets have a diverse product offering, meaning that they can offset losses made on one product (i.e. milk) against others. Moreover, the power of supermarkets relative to processors – and the involvement of the latter across both aligned and non-aligned chains – means that supermarkets may be able to exert influence both directly, within aligned chains, and indirectly, within non-aligned chains.

5.2.5 Summary of Buyers' Demands

The broad 'social problem' of dairy farming in the UK was defined (in section 5.1) as 'the provision of food at scale', and the solution of this problem was defined as 'the domestication of dairy cattle for the production of milk to conventional (i.e. not organic) standards by (and as a primary commercial activity of) organised agricultural enterprises, for purchase by milk processors'. Defining this problem at the sector level serves to outline the "outer boundaries" of the socio-technical regime for UK dairy farming (Dosi 1982, p.154), within which a range of clusters was identified (5.1.2). Although these clusters share this common goal of 'providing food at scale', at the subsector (i.e. individual cluster or farm) level of analysis a spectrum of goals nested within this broader regime-level goal will exist, identified with the different socio-technical system inputs and outputs of farms operating within these clusters. Put differently, intensive, intermediate and extensive farms will tend towards distinct system goals.

Similarly, the various actors within the value chain for liquid milk, while broadly agreeing on the overarching goal of 'providing food at scale' will – at the subsector level of analysis – emphasise to varying degrees different dimensions of this goal. In order to determine the influence of buyers' demands upon farms (through analysing the correspondence between farm inputs/outputs as a proxy for 'system goals' and buyers' demands; 4.2) it is necessary to characterise these demands and enumerate the mechanisms through which buyers exercise power to encourage compliance with these demands. From the foregoing overview of the value chain for milk (5.2), it is clear that milk buyers define the 'problem agenda' of dairy farming using the following (interrelated) dimensions:

- **Security of supply** – The milk buyer's goal is to procure sufficient volumes of liquid milk to satisfy customers' demands throughout the year. Supermarkets, for example, may seek to manipulate the volumes of milk supplied by farmers (which tend to fluctuate seasonally throughout the year due to the seasonal variations in production associated with different farm systems, see 5.1.2) so that these match consumer

demand, which is broadly level throughout the year. Traditionally, production in the UK has peaked in the Spring (the so-called ‘Spring flush’⁵⁸).

- **Product characteristics**, including the composition and constituent content of the milk, and food hygiene and safety standards. Notably, there is a relationship between buyers’ demands regarding security of supply (volumes and seasonality) and buyers’ demands regarding product characteristics. Increases in the volume of milk produced per cow typically accompany reductions in the constituent content of the milk.
- **Production characteristics**, which may include specific demands concerning both the performance of farms with regard to environmental impacts and animal welfare, and farms’ efficiency and production costs.

Changes along these dimensions are often changes of scale (e.g. an incremental tightening of existing demands regarding, for example, hygiene standards) rather than changes of kind (e.g. the introduction of a requirement for ‘locomotion scoring’ of cattle, where no previous requirement had existed). These dimensions of variability and change in technologies (outlined above, 5.1.2) are *related*, but they are not identical. The analysis will involve relating changes in socio-technical system functioning (using the dimensions in 5.1.2) to changes in demands (using the dimensions above). Significantly, there may be several possible technological approaches to satisfying buyer demands, and the approach selected may vary from system to system.

5.2.6 Distinctions in Governance Conditions within Different Value Chains

The overview of the value chain for milk (above, 5.2) also highlights the differences between governance conditions within aligned and non-aligned value chains, along the various dimensions of value chain governance with which this study characterises value chains (namely, depth and pervasiveness, sanctions, trust and the separation of powers; summarised in 4.3.2). The ability of buyers to secure compliance with their demands is a product of these governance conditions. This section describes in greater detail both the relationships between these dimensions and the distinctions (along these dimensions) between aligned and non-aligned value chains that will be deemed relevant for the analysis.

The depth and pervasiveness of rules – “Depth” refers to “the extent to which [governance] affects the core activities of individual parties in the chain”, while “pervasiveness” refers to “how widely over the chain ... power is exercised” (Kaplinsky and Morris 2001, p.32). Broadly,

⁵⁸ *ibid.*

rules that do not require 'deep' or 'pervasive' change will be more readily complied with. For the purposes of the analysis:

- The depth and pervasiveness of given rules will vary from cluster to cluster – because different systems will have different 'core activities' (5.1) – and the influence of buyers upon farms will therefore depend upon farms' 'starting points' and must be considered relative to their clusters (see 4.2)
- Rules regarding the security of supply and production characteristics may relate to both system inputs and system outputs (and may therefore affect farms' 'core activities'). By contrast, rules regarding product characteristics will typically only relate to outputs and may therefore be complied with through a variety of methods, without necessarily involving changes to core activities. Buyers' demands regarding the security of supply and production characteristics (e.g. the adoption or rejection of specific technologies or standards) will therefore typically be 'deeper' than those regarding product characteristics.
- Rules that persist over time are more likely to be 'deep' and 'pervasive' than rules requiring 'one off' or reversible changes at a fixed point in time, particularly where such rules mandate recurring, enduring or possibly escalating changes.
- If rules demand continual improvements and/or serve to raise best practice standards across the market (i.e. capturing in an ever-wider number of participants through the creation of expectation or co-ordination effects, see 4.3.1) this may increase their depth and pervasiveness. The practice of benchmarking (5.2.2 above) may provide an example of this. As Tesco suggest: "We set targets for improvement each year, and monitor important areas such as lameness, cleanliness and cow health in each farm ... Examples of improvements we have driven across the group include cow mobility (4.63%) and reduced abrasions (4.71%)".⁵⁹

The separation / concentration of powers – Patterns of technological change will be attributed to buyer power where such power is exercised through rules developed, administered or enforced by buyers, which specify product, production or security of supply requirements that are in excess of industry wide 'legal minima' stipulated by authorities and agencies (such as Defra, The Environment Agency etc). Where buyers perform two or more of these functions (development, administration or enforcement) this will indicate a concentration of power. On the one hand, such a concentration may enhance the buyer's ability to influence farmers,

⁵⁹

https://www.tescopl.com/assets/files/cms/Food_news_results/Agri_content/Tesco_welfare_standards_for_dairy_cows.pdf

through either increasing the effectiveness of sanctions (see below) and/or increasing farmers' reliance on the buyer (see below). On the other hand, it may negatively affect conditions of trust (see below) within the chain.

Sanctions – The analysis will consider the following sanctions, implemented by buyers in order to influence farmers with regard to the security of supply, production standards and product standards:

- **The power to exclude** – The punitive value of losing (or of being refused) a contract may be measured crudely in terms of opportunity cost. The opportunity cost associated with losing (or failing to secure) a contract will be a product of the milk price paid under the contract and the milk volumes demanded by the buyer, as well as the availability of an alternative contract (and the price paid under that contract compared with the current contract).
- **Base prices for milk** – A high base price (relative to average market prices) may be (broadly) indicative of buyer demand for increased volume while a low base price will be indicative of buyer demand for reduced volume. High, and *stable*, milk prices may be more effective in influencing farmers than low and/or volatile prices.
- **Bonuses** for increased production and **penalties** for underproduction.
- **A / B pricing** – The buyer may pay an 'A' price for each litre of milk supplied up to a certain volume, and a lower ('B') price for each additional litre of milk supplied. The effectiveness of such measures may depend upon where the levels of the A and B prices are set relative to prices available in the wider market.
- **Seasonality payments** – adjustments to base prices to either reward or penalise production beyond certain limits at specific times of the year. The effectiveness of such payments will vary from system to system given the differences in production profile inherent to all year, Autumn and Spring calving models (5.1, above).

Trust – For the purposes of this study, trust refers to participants' confidence in the *continuity, reliability and predictability* of the operation of the value chain (with trust being enhanced [diminished] by conditions that support [threaten] such continuity, reliability or predictability). As noted earlier (3.6.3), Kaplinsky and Morris propose a number of "data points" that may be referred to when assessing levels of trust within a value chain. **Table 5f** summarises these data points, alongside a number of questions that may be considered when examining contractual and broader relationships between farmers and buyers.

Table 5f: Assessing Trust Relations in the Value Chain

	Low Trust Chains	High Trust Chains	Relevant Questions for Analysis
Length of contracts / trading relationship	"Short-term"	"Long-term"	<ul style="list-style-type: none"> • How long has the farm been supplying the buyer?
Modes of inspection used in accepting incoming materials	"Inspection on delivery"	"Little or no inspection on delivery for most parts"	<ul style="list-style-type: none"> • How frequently and intensively are producers inspected by buyers? • What information is gathered? • How does the buyer use this information (e.g. for benchmarking purposes)?
Degree of reliance which firms have on each other	"Supplier has many customers, and customer has multiple sources"	"Few customers for supplier and single- or dual-sourcing by customer"	<ul style="list-style-type: none"> • How readily available are alternative buyers if farmers are unhappy with their current buyer? • How readily available are alternative farmers if buyers are unhappy with a farmer's performance?
Types of technical assistance flowing along the chain	"Expertise rarely pooled, and assistance only when paid for"	"Extensive unilateral or bilateral technology transfer over time"	<ul style="list-style-type: none"> • What types of assistance do buyers offer (e.g. technical or financial assistance, producer groups, training days, research centres, etc)? • How 'deep' is such assistance (e.g. does it extend beyond the achievement of product outcomes to influence production processes)? • How 'pervasive' is such assistance (e.g. is it extended to all farmers within a producer group, or only to a subset of farmers, who satisfy certain requirements)? • How is the scope of such assistance determined (e.g. do farmers play a role in defining the type of assistance they require, or is this determined unilaterally by buyers)?
Nature and methods of communication along the chain	"Infrequent and through formal channels. Narrowly focused on purchasing department"	"Multi-channelled, including, engineers, personnel department and top management; frequent and often informal"	<ul style="list-style-type: none"> • What are the channels and frequency of communication? • Is such communication bilateral or unilateral?
Determination of prices	"Adversarial, with hiding of information"	"Non-adversarial with 'open books'"	How are prices calculated (i.e. are prices calculated on a discretionary basis, or according to a transparent formula, such as 'cost of production')?

Source: Adapted from Kaplinsky and Morris (2001), p.74. NB: The term 'reliance' is used here (and throughout this study) in preference to Kaplinsky and Morris's term 'dependence'. This is for the avoidance of confusion with the term 'path dependence' (Chapters 2 and 3).

Kaplinsky and Morris suggest that the effect of rules upon behaviour "is a function of sanctions and legitimacy [i.e. trust]" (Kaplinsky and Morris 2001 p.74). They add that: "the effectiveness of a governor's command of a chain does not only reflect the power of its sanctions, but also the trust which its suppliers or customers have in it. This is particularly important in assessing the long-term viability of the chain" (ibid. p.73).

This study is not primarily concerned with the *viability* of the UK value chain for liquid milk. However, the *duration* of relationships between chain participants *is* a significant variable to

consider when attempting to understand whether and how power influences technological change, which often occurs over long periods of time. For example, where relationships between buyers and farmers are short-lived, it could be that either:

- a) The opportunity for buyers to influence technological change amongst individual producers is limited. Within a low-trust value chain, in which a farmer's failure to satisfy the buyer's requirements may result in their immediate exclusion, technological change on the part of that farmer may be inhibited (i.e. due to their immediate exclusion) and therefore the buyer's ability to influence such technological change is diminished (with respect to the individual farmer, albeit these circumstances may effectively enhance the buyer's ability to influence technological change at the *sector* level if farmers that don't satisfy its requirements thereby fall out of the market altogether); or
- b) The buyer's ability to influence technological change may be increased (i.e. the severity of the sanctions may force producers to immediately comply, rapidly implementing technological changes to meet buyer's requirements in order to avoid immediate sanction).

Whether (a) or (b) occurs may depend upon the availability of alternative buyers in the market (and therefore relates to the buyer's power to exclude, above). If there are no alternative buyers, then the producer may be more willing to comply. Therefore, the "degree of dependence [reliance]⁶⁰" that parties have on each other is both an indicator and a product of trust within the value chain (Kaplinsky and Morris. 2001, p.73). In the context of dairy farming, assessing available alternative buyers for dairy farmers is a matter of both geographical circumstances and market concentration. Indeed, "the fact that in some parts of the country farmers do not necessarily have access to alternative milk buyers reduces the extent to which there can be competition for demand for raw milk." (House of Commons 2011, **Ev 3**)

Whether (a) or (b) occurs may also depend upon the speed and ease with which the required technological changes can be achieved, and therefore upon the existing technologies in use (see above, with regard to the depth and pervasiveness of rules and different 'core activities' associated with different clusters of farms; **5.1**), as well as the availability of financial and other resources. Therefore, when assessing the effectiveness of buyers' sanctioning power it may also be necessary to consider this in relation to the depth of the change that such power is directed at securing. If buyer requirements necessitate shallow changes, then the farmer may make such

⁶⁰ The term 'reliance' is used in this study in preference to Kaplinsky and Morris's term 'dependence'. This is for the avoidance of confusion with the term "path dependence" (**Chapters 2 and 3**).

changes even when relatively little power is exercised. If deep changes are required then the farmer may not be willing/ able to make these, even in the face of an extremely powerful buyer.

The duration of relationships – and the role of trust in sustaining them – also raises the question of *how* technological changes are negotiated. Conditions of low trust may be characterised by unilateral action, whereas conditions of higher trust may be characterised by bilateral interaction or collaborative relationships. Within such relationships, producers may be supported in meeting requirements, as opposed to being coerced (see **Table 5f**, “types of technical assistance”). As Kaplinsky and Morris note: “in modern flexible production systems ... trust becomes increasingly important, and failure to reach the required level of standards does not automatically result in the sanction of exclusion; instead executive governance is exercised to assist the transgressing party to achieve the required levels of performance” (ibid. p.31-32).

Within such collaborative situations, however, assessing the scale and effect of power may not be straightforward. Collaboration should not be confused with equality or parity in bargaining power. Collaboration that results in parties ‘meeting in the middle’ may be more indicative of parity between those parties than collaborative efforts that result in an outcome identical to that initially requested by the buyer. Moreover, the provision of ‘support’ should not automatically be interpreted as diminished power on the part of the buyer. Providing support may simply offer a more politically-expedient means of achieving the desired outcome, in particular when such support accompanies significant data gathering by buyers (as in the case of benchmarking exercises; **5.2.2**). An assessment of collaborative efforts, and the provision of support by buyers in the dairy value chain, should consider these possibilities.

Through understanding such collaboration as a process of “collective stabilisation and closure” of technological frames (Meyer and Schubert 2007, p.35; **4.3.3**), the assessment of buyer influence upon farms moves beyond a consideration of the correspondence between farm system goals (as these differ amongst different clusters; above **5.1.2**) and buyers’ demands (as these differ along the dimensions outlined in **5.2.5**), to include a consideration of how these interact and inform one another and of the beliefs or meanings that underpin these goals.

Indeed, although evidence of “sustained governance” (Kaplinsky and Morris 2001, p.30) may be relatively easy to glean by reference to the data points in **Table 5f**, it is suggested that they may not provide a complete picture of power relations between chain participants. It is suggested that ‘trust’ is an imperfect proxy for ‘legitimacy’ (being centred on a regulative perspective of the nature of governance; see **3.6.3**). As outlined above, the duration of the relationship between

a governor and those whom it governs may not provide conclusive evidence that the former is supported by the latter, but may instead indicate mere acceptance or tolerance of the situation by the latter, due to the absence of an alternative. 'Trust' may therefore provide an imperfect depiction of the true nature of the relationship between chain participants. This is significant in the context of the present study, which is centred on understanding whether and how buyers influence producers. Conceptual tools drawn from SCOT (see 4.2.3), namely the notion of 'technological frames', may illuminate the analyst's understanding of trust conditions, through providing a consideration of not only formal transactional interactions between buyers and farmers but, moreover (and more informally), the way that farmers think and feel about such relations.

With that in mind, in conjunction with these data points, it will be useful to examine chain participants' perspectives regarding such rules (including, for example, whether they regard prices or pricing mechanisms as 'fair'), on the basis that these may provide a more complete picture of the relationship between – and relative power of – chain participants. These perspectives will be captured at interview, through questions directed at eliciting information regarding farmers' 'mindsets' (4.2.3, 5.1.1), not only in relation to technologies but, moreover, in relation to the regulative framework within which they operate. This will provide an indication of the process of stabilisation and closure of technological frames.

Finally, immediate and punitive exclusionary sanctions are not the only possible cause of short-lived, low-trust relationships. Positive sanctions (i.e. prices and bonuses) may also be a factor in the duration of relationships. If buyers do not offer an attractive and/or stable price, producers may 'shop around' in search of a better alternative (although farmers are nearly always "price takers" – DairyCo 2011a p.3). High-trust situations may therefore be characterised by higher, more stable and transparent prices. Where prices are stable over the long term (as with cost of production pricing associated with aligned contracts) then this may also impact upon technological development as it enables farmers to plan ahead with regard to investment decisions. The strength of both positive and negative sanctions should therefore be borne in mind when assessing the extent to which 'collaboration' is truly 'collaborative'.

Chapter 6:

Data collection and Case Study Approach

This chapter describes the data collection and case study approach adopted in this study. It begins by explaining how the interpretive aims of the study imply a set of indicators and consequently data requirements⁶¹ that can be provided by using a case study approach (6.1). This is followed by an enumeration of the relevant (and available) sources of data (6.2), including an account of the process and reasoning behind the selection of particular farms as the subjects of case studies (6.2.1), as well as a summary of the key characteristics of those farms (6.2.2). The types of data collected and the chosen methods of data collection and analysis are then described (6.2.3, 6.2.4). Limitations associated with this approach are suggested in 6.3.

6.1 Data Requirements and Case Study Approach

As outlined in **Chapter 4**, this study aims to understand the influence of buyers upon patterns of technological change in UK dairy farms through:

- allocating selected dairy farms, as socio-technical systems, belonging to one of three clusters (intensive, intermediate and extensive), by reference to their configurations of technological inputs and associated outputs;
- explaining the mechanisms through which these systems function and are stabilised; and
- identifying and analysing the changing relationships between, on the one hand, changes in these inputs and outputs and on the other changes in buyers' demands over the period 1994-2016.

Understanding these processes requires the collection and analysis of multiple sources of both qualitative and quantitative data. These data requirements, and their relationship with the analytical framework, are summarised in **Table 6a**. The indicators that were chosen were consequent on the discussion in **Section 5.1**, where the key characteristics of dairy farms as socio-technical systems were identified.

Conducting case studies at the farm level provides one method of obtaining such data, enabling the collection of both quantitative data about the technologies used by farms and the conditions

⁶¹ As discussed already (5.1), the research question informed the components that were regarded as 'more important' within the analysis. This in turn informed the primary data requirements of the study.

of value chain governance within which farms operate, as well as qualitative data explaining the farmers' selection of those technologies and the influence of value chain conditions upon that selection. Bearing these data requirements in mind, and considering the interpretive ambitions of this study, a case study approach was selected, which was aimed at comparing several cases "... identify[ing] issues within each case and then look[ing] for common themes that transcend the cases" (Creswell 2013, p.101).

Table 6a: Data Requirements

Analytical Layer	Data Requirements
Layer 1: Describing and characterising observed technological changes	<p>Evidence of variations and changes in socio-technical system inputs and outputs (between 1994-2016) associated with:</p> <ul style="list-style-type: none"> • Feeding technologies • Buildings and housing technologies • Breeding technologies • Fertility technologies • Milking technologies • Animal husbandry and veterinary medicine technologies • Production cycle ('calving pattern') technologies • Waste management technologies.
Layer 2: Identifying the mechanisms underlying technological changes	<p>Evidence of interactions between the technological components described above, explaining both positive feedback effects and reverse salients resulting from these interactions.</p> <p>Evidence of variations and changes in other system components (resources, institutions and actors), and their relationship with farms' selected technological inputs (i.e. their contribution towards positive feedback effects and reverse salients), including:</p> <ul style="list-style-type: none"> • Labour resources • Knowledge / skills / beliefs embedded in farmers and their labour force • Financial capital • Land and physical location • Local climate • Transport infrastructure and links. <p>Evidence of the sequence in which such technological changes were required and introduced.</p>
Layer 3: Determining the contribution of buyer power to the above	<p>Evidence of buyers' demands, drawn from:</p> <ul style="list-style-type: none"> • Contracts for the sale of milk, including: <ul style="list-style-type: none"> • Base prices for milk • Bonuses and penalties for product and production characteristics • Broader contract conditions and terms of engagement. • Formal (documented) and informal communications and relations between buyers and farmers (i.e. the 'data points' outlined in Table 5f; 5.2.6), including farmers' accounts of relationships between changes in their selected technological inputs / outputs and changes in buyer demands. <p>Evidence of milk prices at the sector level (because the sanctioning effect of individual milk prices is likely to depend upon how high / low those prices are relative to broader market prices).</p> <p>Evidence of the sources of technological inputs.</p>

6.2 Data Sources

Chapters 4 and 5 served to ‘bound’ both the broader system (i.e. the UK value chain for liquid milk) within which farm case studies are situated, and to bound these case studies themselves within the following categories (Creswell 2007, p.73):

- Aligned intensive farms
- Aligned intermediate farms
- Aligned extensive farms
- Non-aligned intensive farms
- Non-aligned intermediate farms
- Non-aligned extensive farms.

Access to the ‘Milkbench+’ database – owned by the Dairy Division of the Agricultural and Horticultural Development Board (AHDB)⁶² – was secured, making it possible to identify farms that occupied these clusters, which could form the subject of case studies.

6.2.1 Milkbench+ Database and the Selection of Case Studies

Between 2007/8 and 2012/13, AHDB provided a benchmarking service to UK dairy farms, called ‘Milkbench+’. This involved the annual collection of physical and financial data from a self-selecting⁶³ sample of over 350 UK dairy farms, yielding a series of cross-sectional datasets that provide a 5-year snapshot within the longer 22-year snapshot of this study (see 4.1). For the purposes of this study, AHDB agreed to share Milkbench+ data relating to a limited number of variables. The variables that were selected were those that best served to define the clusters (by reference to the characterisation of dairy farms as socio-technical systems, in 5.1) and are listed in **Appendix 6B**.

⁶² Previously called ‘DairyCo’, but re-branded as ‘AHDB Dairy’ halfway through the study. For the sake of simplicity it is referred to throughout as ‘AHDB’ (except where referring to publications produced under the name ‘DairyCo’).

⁶³ Although not a random or stratified sample, it is relevant that the participants in the survey were subjected to the same (industry-wide) forces as non-participants and may therefore, to that extent, be regarded as being representative of the broader population of dairy farmers. The extent to which the Milkbench+ dataset was representative of the broader UK population of dairy farmers is considered in greater detail in **Appendix 6A**.

Principal Component Analysis (PCA) and cluster analysis was performed upon the 2012/13 Milkbench+ dataset in order to derive three clusters corresponding to 'intensive', 'intermediate' and 'extensive' farms. Data for a single year were used, as opposed to data averaged across each year of the dataset, because using such averages would have resulted in a much smaller sample size (only 15 farms submitted data returns for every year of the Milkbench+ survey), whereas using 2013 data yielded a sample size of 285 farms on conventional (i.e. not organic), liquid contracts. Moreover, data for some variables had been retrospectively overwritten from one year to the next (see further, 6.3 – limitations – below) meaning that it was not possible to derive reliable averages across the 2007-13 period for many variables.

PCA can be used to reduce the dimensions of data, and can therefore help to distinguish 'signal' from 'noise' within large, complex datasets, focusing the analysis on those dimensions that account for the most variance in the data (Smith 2002). In a dataset containing a large number of variables, it is possible to identify a smaller number of 'principal components', which are essentially those different combinations of variables that together account for the largest amount of variance within the dataset. PCA therefore enables the analyst to determine relationships amongst numerous variables simultaneously whereas, "traditionally, we would use a series of bivariate plots (scatter diagrams) ... to try and determine any relationships between variables... [which] for large datasets ... is not feasible" (Richardson 2009, p.3).

AHDB had previously performed a PCA and cluster analysis of the Milkbench+ dataset (DairyCo 2012a), resulting in the development of the farm categories included in **Box 5b (5.1.2)**. Although AHDB's methodology provided a valuable reference point when conducting the PCA, the approach decided upon in this study – unlike the one used by AHDB – excluded the use of output variables⁶⁴ to identify principal components. Instead, principal components were developed from the following input variables (selected by reference to 5.1.2; **Table 5a**, and to AHDB's own PCA):

- Housing period in weeks
- Number of milkings per day
- AI and breeding costs per cow (£)
- Feed per cow in DM weight (Kg DM)
- Compound feeds fed per cow in DM weight (Kg DM)
- Number of full dairy grazing weeks
- Fixed Costs per cow (£)
- Variable Costs per cow (£)

⁶⁴ AHDB had included 'milk production', 'Yield per cow', 'Milk price p/l' and 'Protein content of milk' as variables used to develop principal components.

Having extracted principal components from the data, cluster analysis was performed, using these principal components as clustering variables.

Figure 6a provides a visual representation of these three clusters. Farms are plotted along the axes 'Feed per Cow' in kilogrammes of dry matter (KgDM) and 'Housing Period' in weeks of the year, and colour-coded according to the cluster to which they were allocated. The right hand side of the scatterplot shows a number of intensive farms that house cows for 52 weeks of the year, and feed relatively larger quantities of feed per cow compared with the rest of the sample. At the other (left hand) extreme of the scatterplot lie the extensive farms, characterised by low feed inputs and short periods of housing (in one case, below ten weeks of the year).

Descriptive statistics that outline broad differences between these clusters across key variables are included in **Table 6b**, alongside mean values for the entire sample, and are summarised as follows:

- Intensive farms had the highest housing periods, feed per cow, stocking rates, average numbers of dairy cows and yields per cow, and the lowest number of grazing weeks
- Intermediate farms had the highest AI and breeding costs, the lowest stocking rate and the lowest average number of dairy cows
- Extensive farms had the highest number of grazing weeks, and the lowest housing period, feed per cow, AI and breeding costs, and yields per cow.

Figure 6a: Farm Clusters Developed using PCA / Cluster Analysis

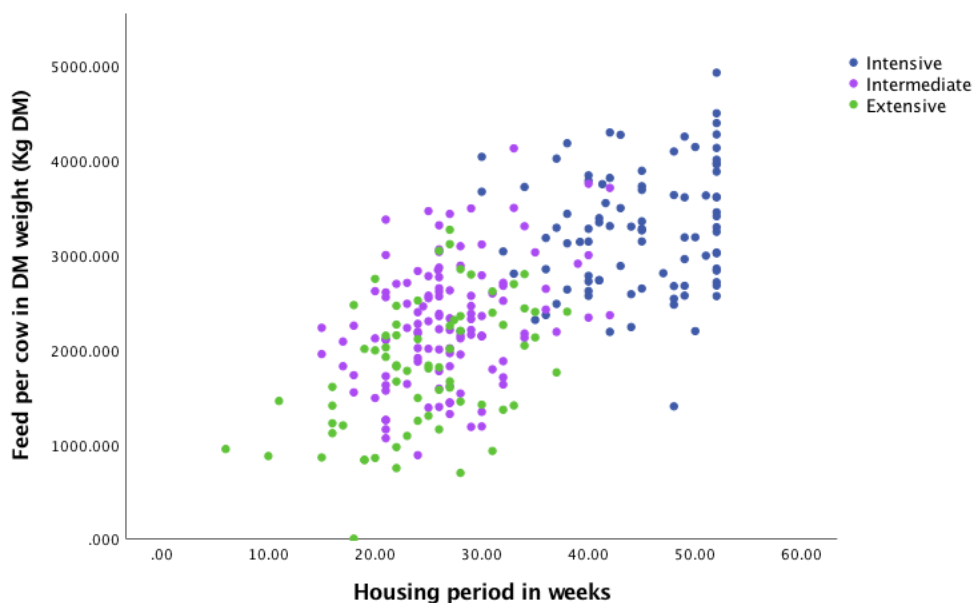


Table 6b: Descriptive Statistics: Mean Values for Key Variables Across Clusters

		Housing period in weeks	AI and breeding costs per cow (£)	Feed per cow in DM weight (Kg DM)	Number of full dairy grazing weeks	Yield per cow (litres per year)	Dairy stocking rate (LU/ha)	Average number of dairy cows
Intensive	Valid	90	90	90	90	90	87	90
	Missing	0	0	0	0	0	3	0
	Mean	44.59	34.834	3261.12302	7.0550	8952.65632	2.36768	248.07
	Std. Deviation	6.39677	14.49124	649.145412	5.87583	886.215493	.687365	119.403
	Variance	40.919	209.996	421389.766	34.525	785377.900	.472	14257.106
Intermediate	Valid	117	117	117	117	117	117	117
	Missing	0	0	0	0	0	0	0
	Mean	26.8581	40.0988	2285.84636	24.8283	7458.91647	1.75755	147.94
	Std. Deviation	5.49459	18.10156	636.925050	5.59772	1247.90378 3	.470939	78.334
	Variance	30.191	327.667	405673.520	31.334	1557263.85 1	.222	6136.155
Extensive	Valid	69	69	69	69	69	69	69
	Missing	0	0	0	0	0	0	0
	Mean	24.5565	21.2602	1808.23553	26.4682	6705.91194	2.08934	228.44
	Std. Deviation	6.50700	9.43727	684.503429	6.47445	1353.41948 2	.580846	151.244
	Variance	42.341	89.062	468544.945	41.918	1831744.29 4	.337	22874.814
[Farms not allocated to clusters]	Valid	4	8	8	8	9	9	8
	Missing	5	1	1	1	0	0	1
	Mean	24.5000	37.3243	1889.22751	26.9541	7154.66426	1.92603	202.83
	Std. Deviation	8.26640	24.22519	804.818154	7.74176	1140.87271 9	.824173	133.917
	Variance	68.333	586.860	647732.261	59.935	1301590.56 1	.679	17933.716
Whole Sample		Mean	31.9568	33.7752	2467.70130	19.6542	7738.70947	2.03234
								200.78

Having developed these clusters, thirty farms were shortlisted from them to form the basis of potential case studies.

The selection of farms for case studies followed the approach recommended by Creswell, namely, cases were selected “that show different perspectives on the problem, process or event ... [as well as] ordinary cases, accessible cases, or unusual cases” (Creswell 2007, p.75). Therefore, the shortlisted farms were those that appeared to provide “representative” examples of each cluster (i.e. the findings from which may therefore be generalisable to the broader population; Creswell 2007 p.74), as well as those that had shown some evidence of movement from one cluster towards another over the period 2007-2013; or appeared to be significant outliers / extreme examples of the extensive or intensive clusters. The assessment of whether farms were representative examples or outliers was made by reference to the farms’ position on scatterplots such as the one represented in **Figure 6b**, above, in addition to comparing changes in these farms over the period covered by the Milkbench+ dataset.

AHDB contacted these farms in order to arrange farm visits and interviews. Out of the farmers contacted, eight agreed to be interviewed. The case study sample was therefore supplemented by farms drawn from outside of the Milkbench+ dataset, which fulfilled the same criteria outlined above. Appropriate farms were identified from a study of dairy farming trade publications and news services, and online farming forums. One farm – **Farm P** – was drawn from a previous research conducted by the author in 2014.⁶⁵

6.2.2 Summary of Case Studies

The main features of farms included in the study (cluster membership, value chain, and whether they were included in the Milkbench+ dataset) are summarised in **Table 6c**, while **Table 6d** provides a breakdown of these farms by category.

Given the study’s objective of identifying the influence of buyers upon technological change in farms across aligned and non-aligned value chains, the intention was to interview equal numbers of aligned and non-aligned farms. Moreover, the proportions of intensive (31.25%), intermediate (50%) and extensive (18.75%) farms represented in the case studies broadly mirror the proportions of these farms within the Milkbench+ dataset – which contained 90 intensive (31.58%), 117 Intermediate (41.05%), and 65 extensive farms (22.81%) – albeit extensive farms and intermediate farms were slight under- and over-represented, respectively.

⁶⁵ In the form of a pilot study of technological change in UK dairy farming which served as the dissertation component of a Masters programme in Science and Technology Policy at the University of Sussex.

Table 6c: Summary of Farms Included in the Study

	Cluster	Value Chain	Included in Milkbench+ dataset?
Farm A	Intensive	Aligned	No
Farm B	Intermediate	Non-aligned	No
Farm C	Intermediate	Aligned	No
Farm D	Intermediate	Aligned	No
Farm E	Intermediate	Aligned	No
Farm F	Intensive	Aligned	No
Farm G	Extensive	Non-aligned	No
Farm H	Intermediate	Non-aligned	Yes
Farm I	Intensive	Non-aligned	Yes
Farm J	Intermediate	Non-aligned	Yes
Farm K	Extensive	Aligned	Yes
Farm L	Intermediate	Non-aligned	Yes
Farm M	Intensive	Non-aligned	Yes
Farm N	Intermediate	Non-aligned	Yes
Farm O	Intensive	Aligned	Yes
Farm P	Extensive	Non-aligned	No

Table 6d: Breakdown of Farms Included in the Study by Category

	Aligned	Non-aligned	Total	Proportion
Intensive	3	2	5	31.25%
Intermediate	3	5	8	50%
Extensive	1	2	3	18.75%
Total	7	9	16	100%
Proportion	43.75%	56.25%	100%	

6.2.3 Methods of Data Collection

Data were collected through face-to-face semi-structured interviews, or “guided conversations” (Yin 2018, p.118), with farmers, of approximately 1 – 1.5 hours in length. These were conducted on-farm, which offered the interviewee the comfort and security of familiar surroundings in which to discuss potentially sensitive issues. Interviewees were briefed in advance regarding the broad subject areas to be covered within the interview and were provided with an information sheet outlining the scope of the study (see **Appendix 6C**). One strength of interview evidence, compared with purely documentary data, is that it offers the potential for eliciting information regarding the subject’s “explanations as well as personal views” (ibid. p.114) on a range of potentially complex and sensitive topics. Interviews also presented an advantage over surveys, for example, in teasing out complex case histories.

Interviews with farmers incorporated a range of questions regarding farm characteristics (herd size, output per cow, marketing arrangements for milk etc) and the technologies and innovations employed by the farmer, complemented by a series of more 'open' questions aimed at capturing the complexity of individual farm circumstances, histories and contexts (see **Appendix 6D**). Interviews were recorded – with the permission of the interviewees – and later transcribed for analysis.

Additional, documentary evidence was collected during farm visits for the purposes of triangulation (Yin 2018, p.128). This included: copies of contracts for the sale of milk, copies of ration formulation reports, and summaries of farm accounts (although not all farmers were willing or able to provide all of this supplementary information). Data collected through semi-structured phone and face-to-face interviews with industry representatives (including processors, farmer representatives and industry bodies), as well as quantitative data extracted from the Milkbench+ dataset, provided further data sources for the purposes of triangulation.

6.2.4 Methods of Data Analysis⁶⁶

The method selected for analysing case study data followed the format of producing a “*within case analysis*” of each farm case study, “followed by a thematic analysis across the cases, called a *cross case analysis*” (Creswell 2013, p.101; Eisenhardt 1989; 539-540).

Systematic textual analysis was performed on the individual interview transcriptions. Transcriptions were coded, i.e. aggregated into “small categories of information [i.e. ‘codes’]” (Creswell 2013, p.184), which were then used to identify broader “themes”, cutting across case studies. Codes were both “prefigured” (i.e. implied by the analytical framework, e.g. categories of technological and non-technological components were ‘codes’; see also Eisenhardt 1989, p.540) and “emergent” from the analysis itself (Creswell 2013, p.179-184). The process was iterative, meaning that – having been coded – transcriptions were later reviewed in the light of themes that had emerged through coding and analysis of subsequent transcriptions.

Case studies were enriched using descriptive data extracted from the Milkbench+ dataset, which provided a means of comparing farms against mean values for key variables both for both their particular clusters and for entire the Milkbench+ sample.

⁶⁶ NB: Principal Components Analysis and cluster analysis, used to develop clusters and shortlist farms for interview, have been described above; **6.2.1**

6.3 Limitations of the Data

Because the clusters used within this study were derived from Milkbench+ data for 2013, and detailed historical farm input data were not consistently available (at either the individual farm and sector level) for years not covered by the Milkbench+ dataset (i.e. 1994-2006 and 2015-16), the process of allocating farms to clusters for the years prior and subsequent to 2013 involved a consideration of farmers' testimony, data gathered at interview, and a comparison against published industry averages for inputs such as herd size and outputs such as yield per cow.

There are further limitations associated with basing the clusters on the Milkbench+ data for a single year, insofar as the composition of these clusters may therefore have been influenced by volatility associated with short-term weather conditions (which might vary considerably by region on an annual basis) or by short term movements in market prices for feed inputs. Producing clusters from data averaged over the entire 2007-2013 period might have smoothed such volatility. However, using data averaged over the period 2007-2013 would have resulted in a much smaller sample size as only 15 farms submitted data returns for every year covered by the Milkbench+ survey. Moreover, this approach would have been complicated by the fact that data for some variables – such as 'contract type' – had been retrospectively overwritten from one year to the next.

Further, the use of PCA and cluster analysis to develop 'clusters' of farms corresponding to intensive, intermediate and extensive farm systems provided an approximate rather than a precise or definitive method of deriving clusters, because it relies upon the use of scale variables, rather than doing so by reference to the use or non-use of certain technologies or combinations of technologies. This is demonstrated by **Figure 6b**, which shows clear overlaps between the various clusters.

However, notwithstanding the above limitations, the analysis of the Milkbench+ dataset was adequate for the purpose of producing approximate clusters from which to shortlist farms for more in-depth interviews.

Finally, both documentary and interview evidence may contain biases (Yin 2018, p.115; p.121). Interviews create the potential for response bias, while the self-selecting nature of the Milkbench+ sample, from which half of the interviewees were drawn, demonstrated further potential for bias: farmers who were willing to be interviewed may have been those with an 'agenda' (i.e. who held particularly strong views that were not representative of the broader population). A further limitation was the absence of interviews with farmers who had exited the sector due, for example, to persistent conditions of low milk prices.

Chapter 7:

Technological Change in Intensive Farms

This chapter considers patterns of technological change in intensive farms and the influence of buyer power upon such patterns. A number of farms in this study that were categorised within the 'intensive' cluster at the time that the fieldwork was conducted (2016) appear to have operated intensive systems throughout the duration of the study period (1994-2016), albeit differences in rates of change within this cluster could be observed. The following analysis identifies some common themes that can be observed amongst these farms with regard to the changes in system inputs and outputs, the positive feedback effects that explain these changes, and the influence (or lack of influence) of buyer demands upon them.

Positive feedback effects, namely, complementarity effects that result from interactions between different technological components; investment effects; expectation and co-ordination effects are considered first (7.1). Feedbacks resulting from interactions between technological components and other socio-technical system components, specifically resources (including knowledge and skills, labour, and physical resources) and institutions (farmers' beliefs) are considered next (7.2). This is followed by an examination of the successful influence of buyer power upon system reproduction (7.3), by reference to conditions of value chain governance, exercised through or against these positive feedback mechanisms, which is then contrasted with instances in which buyer power has been unsuccessful (7.4) in influencing the extent, rate or direction of technological change.

7.1 Interactions Between Technologies

Complementarity effects resulting from the interaction between breeding, feeding and housing technologies were particularly pronounced amongst intensive farms. Notably, these farms typically housed their cattle for a large proportion of the year, in order to support the performance of the high-yielding Holstein cows that they favoured (which are generally less hardy than other breeds; see 5.1.2, Table 5a), and to enable greater control over the cows' diets (to further boost their performance). The goal of these systems (as a product of system inputs and outputs) could be summarised as 'maximising output per cow'.

These complementarity effects were bilateral as the high-yielding potential of the Holsteins in turn supports the performance of the feeding and housing technologies used (in the words of

Farmer I⁶⁷: “That type of cow does seem to suit that type of system” and **Farmer P**⁶⁸: “the bigger [i.e. Holstein] cows are more efficient at converting concentrate”). There was also evidence of these technologies interacting with milking technologies (in terms of both milking frequency and method). In particular, the introduction of milking robots typically accompanied a move to permanent housing in order to maximise the performance of the robots (i.e. for systems that had introduced robots an additional system goal as to ‘maximise yield per robot’).

Evidence of reverse salients could be observed in many cases, as farms appeared to be approaching certain boundaries associated with the intensive system, with the performance of some system components ‘falling behind’ relative to others (e.g. some farms were encountering the physiological limits of the cattle, or physical limits in terms of stocking density, housing and waste management). These reverse salients had prompted the search for – and selection of – additional complementary technologies (such as those aimed at improving fertility, cow health and welfare, or waste management), which had resulted in further stabilisation of systems through the creation of additional complementarity or investment effects. There follows a more detailed consideration of these feedbacks for each farm.

Farm M⁶⁹ increased herd size incrementally from 140 to 222 between 1994 and 2016 and annual output per cow increased steadily from 7,200⁷⁰ to approximately 11,000 litres per cow over the same period⁷¹ (see timeline **Appendix 7B**), and the farmer suggested that he had been operating an intensive model throughout the study period. The farmer’s account highlighted the bilateral complementarity effects between feeding technologies (using a total mixed ration [TMR], which permitted more precise control over the cows’ feed intake than grazing or self-feed systems) and breeding technologies (“Genetic progress has certainly been very important ... I’ve always bred for milk yield”). Feeding a consistent ration supported the performance of the high-yielding cow (i.e. increasing yields because, in the farmer’s words, “cows like stability”), whilst cows genetically selected for their ability to produce large volumes of milk supported the effectiveness of the TMR in increasing yields. More recently, thrice daily milking had been

⁶⁷ Non-aligned farm, interview date: 31/5/16; Timeline **Appendix 7A**

⁶⁸ Non-aligned extensive farm, interview date 18/7/14, see **Chapter 8**

⁶⁹ Non-aligned farm, interview date: 5/5/16 Timeline **Appendix 7B**

⁷⁰ Compared with UK average yields in 1995/96 of 5,512 litres per cow per milk year; <https://dairy.ahdb.org.uk/resources-library/market-information/farming-data/average-milk-yield/> (pre-1995 figures not available)

⁷¹ Yields per cow for **Farm M** in 2013 were 10,487 compared with the mean for the Milkbench dataset (2013) of 7,739 litres, placing it in the 90th percentile.

introduced, supporting the performance of these high yielding cows (i.e. further increasing their yields).

Reverse salients had emerged within **Farm M's** system, and technological search and selection was being directed in response to these reverse salients. The selective breeding of Holstein cows for maximum yield is frequently associated with the reduced fertility and/or longevity of the cattle (Dillon et al 2006; Pryce et al 2004; Veerkamp and Beerda 2007; Harris and Colver 2001), thus limiting the overall performance of the system⁷² and requiring the introduction of technologies to mitigate these impacts. Within a system based around the breeding and intensive feeding of cattle for yield, the performance of the cattle may therefore fall behind, or out of line, with the performance of the rest of the system over time.

Farmer M confirmed that “fertility has always been an issue” on the farm, and that activity collars (to improve the detection of ‘heat’ in cows) had been introduced in 2002 in response to this. He also reported that short lifespan is “one of the downsides” of the high yielding cow, and that this was – at the time of the interview – influencing his use of breeding technologies. Specifically, he had begun selecting semen from genomically-evaluated⁷³ bulls:

“I one hundred percent believe in genomics ... it's just a big step up... particularly in lifespan, which is what I'm looking at... you can buy [semen from] a bull whose daughters will last 0.5 of a lactation longer than their mothers...”

The farmer's selection of breeding technologies to counter fertility problems appeared to be strongly influenced by his previous investments in breeding technologies, which had driven the herd down an increasingly specialised path in terms of genetics (i.e. investment effects had served to further stabilise the system). Specifically, rather than introducing cross breeding as a means of improving fertility and longevity (through “harnessing the power of hybrid vigour”, DairyCo 2012b p.2:27) he preferred the use of genomically-evaluated semen, which enabled him to preserve the capital value of the herd:

“The cows are locked into higher genetic merit, and that route, and certainly from a capital value point of view if I was to cross [breed] them you would lose quite a lot of that value of the cows ... for the last three years now we've only used genomic[ally evaluated] sires, and I think that over a generation that is going to have more benefit from our point of view than cross breeding.”

⁷² Reduced fertility results in fewer pregnancies and/or a longer calving interval, and therefore reduces the farm's total annual milk production (<http://dairy.ahdb.org.uk/news/news-archive/2009/is-calving-index-important-for-higher-yielding-herds/#.Vqc5OBGrbzI>). Reduced longevity means fewer lactations per cow, meaning reduced output over the lifespan of the cow.

⁷³ Genomic evaluation more accurately predicts a cow's genetic merit than previously available technologies, <https://dairy.ahdb.org.uk/news/news-archive/press-releases/2012/january-2012/genomics-launched-to-dairy-industry-at-the-british-cattle-breeders-conference/>

There was a further, related, suggestion that the system – through incremental intensification – was approaching certain limits with regard to yield per cow:

“[We managed a] ten percent per year output increase ... for the first ten years or so [from 1987 when the farmer moved to the farm]... by [increasing] the cow numbers and yield per cow. If you carry it on it doubles every seven years, [but] it gets more and more difficult [to maintain that rate of growth]”

The farmer confirmed that this was not only due to the fertility and longevity issues considered above, but was also a result of the diminishing returns (in terms of milk yield) on inputs of concentrate feed above a certain level. These limits may also be regarded as reverse salients (i.e. advances in the performance of the cows were lagging behind advances in the performance of other system components) and they appeared to be redirecting technological search and selection with regard to feed inputs (the farmer was altering the feed ration to include higher proportions of forage as opposed to purchased concentrate feeds):

“In ‘06-‘07 we hit 10,000 litres a cow [per annum] on 3.5 tonnes of concentrate [feed, per cow, per annum]⁷⁴... we’re [now] back down under three tonnes a cow ... [we’ve bought 150 acres [of land, which] ... should enable us to grow a lot more forage ... and in the last two or three years we’ve put much more emphasis on grazing cows as well, which is a big step in the right direction in reducing the reliance on bought in feed.”

Buyer demands were also focusing the farmer’s attention on the pursuit of greater efficiency of feed inputs (see below, 7.3.2). Notably, however, this search for improved feed efficiencies does not appear to represent a reversal towards an extensive model of production, but instead it represents change *within the boundaries* (Dosi 1988, p.226-7) of the established system (i.e. the farmer remained committed to an approach based on maximising output per cow, see more regarding the farmer’s beliefs and the way in which he framed the problem and solutions of dairy farming, below 7.2 – 7.4).

Farm F’s⁷⁵ production model was based around the year-round housing of Holstein cows, yielding 10,400 litres per cow⁷⁶, which were fed a TMR to maximise their yield. The farmer summarised the complementarity effects between breeding, housing and feeding technologies

⁷⁴ Mean compound (concentrate) feeds per cow for the Milkbench dataset in 2013 was 1,614 Kg/DM (1.6 tonnes), and **Farm M** was therefore in the 90th percentile for compound feeds per cow.

⁷⁵ Aligned farm, interview date: 20/7/16; Timeline **Appendix 7C**

⁷⁶ Which would have placed it in the 90th percentile of the 2013 Milkbench dataset (albeit this farm was not in the Milkbench dataset)

associated with this model, as follows: “When they’re inside on a controlled diet we can maintain a higher yielding cow.”

The farm further intensified production in 2011 (see timeline **Appendix 7C**) through adopting thrice-daily milking to improve output after milk yields per cow had declined following the departure of a “very good herdsman” and his replacement with “not such a good herdsman” (which may be viewed as a reverse salient that had emerged through a loss of knowledge and skills with regard to fertility – see **7.3.2** – that had resulted in the performance of the cows lagging behind the performance of the rest of the system). Once per cow yields had recovered, thrice-daily milking was retained. Complementarity effects underlying this decision were in evidence, through the interaction of feeding, milking, breeding and fertility⁷⁷ technologies, with increased milking frequency supporting improved fertility through its associated requirement for increased feed inputs:

“We’ve worked hard at transition management.⁷⁸ We’ve got cows ‘calving in’ in better condition. [Milking] three times a day definitely helps with that because the cows are given a bit more [feed], so we can keep the cows in the right condition. So they are transitioning better and getting in calf better.”

This need for increased attention on fertility (which includes the development of skills within the labour force, see **7.2**, e.g. with regard to heat detection) may also be viewed as a response to a reverse salient resulting from the interaction between breeding (Holstein cows genetically selected and bred for high yield) and feeding technologies (feeding a TMR with a high energy content). Feeding an energy dense ration to high yielding cows may cause their performance (in terms of fertility) to fall out of line with the rest of the system; as **Farmer F** explained:

“[The feed ration is] geared up to be reasonably potent ... so you don’t want too many cows giving low amounts of milk otherwise they’ll end up fat ... and they’ll be hard to calve back in... fertility is key here ... the more pregnancies you make, the more milk you’re going to sell. So the quicker they are back in calf, the less chance they have of putting on weight and getting out of condition ... so they are just healthier when they’re going to calve in now... they are in peak condition when they’re going to calve in and their bodies are ready for it.”

Finally, the farmer stressed that the collection and monitoring of data regarding cow health indicators (including mastitis levels, lameness and antibiotics use) was a key activity on this

⁷⁷ NB: “Considerable research into nutrition and fertility performance has pinpointed more pronounced and protracted early lactation energy deficits as a major factor in the lower fertility experienced by many high yielding cows” DairyCo (2012b), p.19

⁷⁸ Transition management involves the measures taken “to ensure the smoothest possible transition from the end of one lactation into full production in the next”; https://dairy.ahdb.org.uk/non_umbraco/download.aspx?media=13856

farm, suggesting that: “herd health is quite high on my agenda all the time”. He explained that his current farming system strongly supports these data collection and monitoring activities, which have in turn supported changes in veterinary medicine and husbandry technologies used on the farm, stating that: “I feel that I can look after them better when they are housed ... they are housed right next to me all the time, and I can monitor them at all times.” In particular, he reported that he had been operating a “monitor group” since taking over responsibility for the farm’s dairy operations. Cows showing signs of mastitis were separated from the herd and placed in this group, and the farmer milked and monitored them individually, whereas previously they would be administered antibiotics and milked with the rest of the herd:

“... It just ensures all the cows are milked out properly and I can just watch these cows, and designate really ‘do they need antibiotics?’... Right now I’m doing a lot of self-curing, so I’m doing work giving cows anti-inflammatories, not antibiotics ...”

Although these activities were supported by both the farmer’s beliefs and by the buyers’ demands (see more below, 7.3), the implementation of increased data collection and monitoring may also be interpreted as a response to a reverse salient that results from (and an expectation effect arising due to) the adoption of an intensive, permanently-housed system.

It has been suggested that permanent housing of cattle creates a higher risk of health disorders and the spread of disease, which would serve to limit the performance of the cattle and thereby hamper the overall enterprise (EFSA 2009; Jackson 2013). Certainly, the public debate regarding intensive indoor cattle farming has centred heavily around health and welfare issues (Jackson 2013). The combination of technologies used on this farm may have therefore created conditions that *necessitate* greater monitoring (either as a means of mitigating the potentially negative consequences of permanent housing or of defending the farm against criticisms from opponents of the housed system). Such concerns appeared to be in the farmer’s mind, for example:

“The dairy industry is one of the few industries that is being blamed for the overuse of antibiotics... third generation drugs... so I’m ready for all that... [and] I’ve stopped using third generation drugs now...” [emphasis added]

Similarly, the farmer was keen to emphasise that the recent introduction of “green bedding” on the farm – a controversial technology involving the use of recycled manure solids⁷⁹ (RMS) as a bedding material for cows – had not introduced health issues, but had in fact accompanied a *reduction* in somatic cell counts⁸⁰ (SCC) to around 140,000. In 2010, average cell counts in the UK

⁷⁹ <https://dairy.ahdb.org.uk/technical-information/buildings/housing/recycled-manure-solids/>

⁸⁰ SCC is an indicator of milk quality and mastitis, with a count of 100,000 or below indicating an ‘uninfected cow’, and 200,000 or above indicating that the cow is ‘highly likely’ to be infected on at least

were 220,000 (Jackson 2013 p.32). Mean cell counts for Milkbench sample for 2013 were 167,290, placing **Farm F** in 25th percentile:

"This is a highly-contentious issue at the moment... [but] if you take a look at our cows you will quickly see that they are pretty clean ... We've had our lowest cell counts on this system... [with] cleanliness scoring, we don't have much of a problem there now that we're on green bedding, because the cows are always clean. We don't have abrasions because we are on deep beds."

Farm I had recently further intensified production, becoming "very much a high-input, high-output ... intensive system", following the introduction of milking robots in 2012, which was accompanied by a move to the year round housing of cattle (see timeline, **Appendix 7A**). These changes increased per cow yields from 8,000 litres to 10,000 litres primarily as a result of the increased milking frequency from twice daily to 2.6 times per day (averaged across the herd).⁸¹ The robots complemented the farm's system, which was already largely indoor-based, with minimal grazing due to resource limitations (see 7.2). **Farmer I** described the complementarity effects that existed between breeding, housing, feeding, production cycle and milking technologies, and emphasised in particular the ways in which housing and feeding technologies supported the performance of Holstein cows (Dillon et al 2003). Investment effects were also apparent, resulting from the specialised and non-transferable nature of the Holstein cow, which – he suggested – is unsuited to other production systems:

"The Holstein breed, and the high genetic cow ... we've found with the robots it is a lot easier to manage that type of cow ... I think a lot of the problems that we used to get with high genetic cows we see less of, because of the system ... And possibly, keeping the cows in [all year] there is generally more consistency [in the diet] ... If we were to go to a more extensive grazing system then, possibly, our cows wouldn't be quite so well suited to that ... if you put them out in a field on a wet, windy day they'd probably just stand there and shiver."

Investment effects associated with milking robots were evident, resulting from the specialised and non-transferable character of robotic milking, which is distinguished from other approaches to milking by the fact that the cow chooses when to walk to the machine to be milked. This characteristic meant that the performance of milking robots was supported on this farm by a permanent housing arrangement, ensuring that the cows were kept in close proximity to the robots, and did not have to walk long distances to be milked.

Although farmers suggested that grazing is possible with robots, the relative non-transferability of the robotic milking system to more grazing based systems was evident: all of the intensive

one quarter of the udder; <https://dairy.ahdb.org.uk/technical-information/animal-health-welfare/mastitis/symptoms-of-mastitis/somatic-cell-count-milk-quality-indicator/>

⁸¹ And placing the farm in the 90th percentile of the 2013 Milkbench dataset

farmers using robots suggested that access to grazing would limit the robots' performance.

Farmer I explained how his system had become increasingly centred on maximising and maintaining the "flow rate" of cows to the robots to ensure maximum yield per robot: "We took the view that ... to keep the flow rate to the robots up it would be better... to just keep them [the cows] in [housed all year]". This represented an evolution in system goals on this farm from maximising yields per cow towards maximising yields per cow and maximising yields per robot.

The farmer also noted that the introduction of milking robots had resulted in new complementarities being created as the production cycle (year round calving) supported the performance of the robots (see further, 7.2):

"We're all year round calving ... we always were really, before the robots, but with the robots installed, [it helps] just to keep a continual, level supply of milk."

The reproductive, incremental nature of technological change on this farm was evident, as were the irreversibilities associated with these patterns of change:

*"I'm not sure about it being us deciding ... 'we have to go intensive' ... it was more a system that suited us... You know, there have certainly been times recently when ... with the high costs of the robots and, you know, things are a bit tight at the minute ... you do question whether it was the right way forward, but **we are sort of committed to it really.**" [emphasis added]*

The introduction of milking robots had resulted in reverse salients, causing the performance of some cows in the herd to fall out of line with the rest of the system, and therefore redirecting search for and selection of breeding technologies:

"Some cows do struggle to become 'robotic' cows because of either their temperament or their teat placement ... so they end up being culled out ... so maybe our focus [in breeding decisions] has changed a little bit ... and particularly with the robots we look at things like teat placement ... in terms of making sure that the robot can find the teats."

The decision to house the cows permanently following the robots' introduction had also reduced the feed efficiency of the system ("we've been aware since we've been on the robots that we've always had quite a high feed rate⁸²"), prompting the introduction of "zero grazing" (where fresh grass is "cut and carried" – using a machine – to feed housed cows). The introduction of this machine represented an investment effect.

⁸² 'Feed rate' is defined as the number of kilogrammes of concentrate feed per litre of milk yield, expressed in kg DM/litre; DairyCo (2012a)

Complementarities between breed, housing, feeding, milking technologies and production cycle were also in evidence at **Farm O**⁸³ (see timeline, **Appendix 7D**). The farm had operated towards the intensive end of the scale since 1994 when it was producing, annually, between 7,000 and 8,000 litres of milk per cow (compared with UK average yields of 5,512 litres in 1995/96⁸⁴), rising to 8,500 to 9,000 litres in 2004 (compared with UK averages of 6,886 in 2004/5⁸⁵). At the time of interview, yields were 13,000 litres per cow.

The farmer had kept Holstein cows since the 1970s and had been feeding a TMR using a mixer wagon since 1996. The farmer explained how the use of this feeding technology supported the performance of his herd of high-yielding Holsteins, enabling him to keep the feed ration “as consistent as possible” and to reduce the length at which forage is chopped in order to increase the volume the cows were able to consume (as shorter chop length reduces the amount of time and energy the cow expends on chewing).

In 2008 the farm replaced its ageing herringbone parlour and housing with three milking robots (a fourth was added in 2014) and a new purpose-built shed to house the cows all year round. This represented intensification in production, and complementarity effects between the robots and housing, production cycle and feeding technologies could be observed. For example, activity and rumination collars that came packaged with the milking robots supported the farm’s existing focus on feeding precision:

“[the collars] highlight cows that have dropped in rumination, and then you’ll go out and find that they’re ill ... but you’ll also find they haven’t visited the robot.”

Moreover, similar to the experience of **Farm I** (above), the introduction of robots was made easier by – and served to further stabilise – the farm’s existing all year calving approach (“we need to keep a consistent number of cows milking all year round, to get the best use out of the robots”). Further, investment effects associated with the specialised and non-transferable characteristics of robots were apparent: the robots had become the focus of the system, with the farmer’s attentions centred on ensuring that other technological components supported the goal of maximising milk output per robot. For example, with the robots installed, the farm moved immediately to year round housing, and the robots also appeared to consolidate the farm’s approach to feeding:

⁸³ Aligned farm, interview date: 12/7/16; timeline, **Appendix 7D**

⁸⁴ <https://dairy.ahdb.org.uk/resources-library/market-information/farming-data/average-milk-yield/>

⁸⁵ *ibid.*

“Because the robot is a very expensive⁸⁶ capital item, you want to be getting sort of two thousand litres a day from the robot as soon as you can ... you will struggle to do that on a grazing system ... You cannot get the yield out of the cow on grass. You need a consistent diet, which is well formulated, it doesn’t change from day to day whether the sun’s out or if it’s raining.”

The effect of this was to further stabilise the system around an intensive model, with input intensity (in terms of stocking rate) also being increased because the farmer was able expand the herd from 140 to 200 cows as a result of year round housing:

“By keeping the cows in and using all silage [it] meant that we became far more efficient in the use of the fields and the cropping that we got off of them ... we then were able to increase the herd up to about 200 cows [over the course of 12 months]...”

The robots had also introduced reverse salients. Following their introduction, the performance of feeding technologies had fallen out of line with overall system goals. Specifically, the fact that cows must choose when to visit the robots had necessitated changes to the composition of the feeding ration (see further 7.3.5):

“You cannot feed a high starch TMR [with robots], which is what we were feeding ... Because ... that ... makes the cows very slow ... [and] they don’t want to get up to walk to the robots to get milked! ... We had to change the diet to have a much more open diet with less starch ... and more protein and more forage, so we have a much higher forage content in the diet, and then ... you have a high starch dairy cake in the robot ... that’s their treat when they go to the robot ...”

Further, the move to permanent housing (and an increased herd size) had directed the search for and selection of new waste management technologies. The farmer had anticipated these when planning the new housing, constructing a ‘slatted’ floor for the cowshed and investing in a robot to push waste through these slats into a cellar excavated beneath the building. The farmer had also introduced ‘slurry bugs⁸⁷’ into the cow’s bedding. These are aimed at (a) reducing mastitis levels (given that “confinement and the increased humidity levels found in livestock housing will lead to increased concentrations of disease-causing pathogens, particularly those which cause mastitis”⁸⁸ i.e. a reverse salient associated with permanent housing which, if unaddressed, will hamper system performance) and (b) locking nitrogen into the slurry (the farmer reported that grass growth had improved and fertiliser use on the farm had reduced by half as a result).

⁸⁶ Farmer O suggested that the price of a second hand robot in 2014 was £50,000, see below 7.3.1.4

⁸⁷ see: <https://www.envirosystems.co.uk/slurry-improvers/>

⁸⁸ <https://dairy.ahdb.org.uk/technical-information/animal-health-welfare/mastitis/working-arena-prevention-of-infection/housing/>

Farm A⁸⁹ had operated an intensive system using Holstein cows since 1994, when yields were 7,500 per cow, albeit it had intensified over the period 1994-2016 to a lesser extent than some of the other farms in the study (see timeline, **Appendix 7E**). The farmer described the system as “fairly high-input”, and was achieving yields of 9,500 – 10,000 litres per cow on the date of the farm visit.

The farm had changed from a Spring and Autumn block calving model to Autumn calving, with the cows housed from the time that they calved (August / September) until the start of April, and were therefore grazed for approximately 20 weeks of the year (Milkbench mean = 19.65). This move was underpinned by complementarity effects between technological components, namely breeding technologies (Holstein cows), calving pattern, and feeding technologies (interacting, further, with physical resources, see **7.2**):

“We ... looked at the Spring calving versus Autumn calving a couple of years ago, and looked at the cost ... And with ... the high-yield type cows we've got, what we found was ... the way we were managing the Spring calving cows, you can't just turn them out to grass and expect them to milk off grass ... We were finding that we were keeping them in for a fair bit of the Spring. So you keep them in until sort of the end of May on a full winter ration ... Instead of feeding cheap grass, you're feeding conserved forage from the previous year. And obviously, there's quite a cost to that.”

Put differently, an Autumn calving model supported the Holstein cattle (with their high energy requirement) as it enabled them to be fed an energy-dense ration when they most required it (i.e. “in the early stages of lactation when the energy demand for production is higher than intake can support, creating an increasingly negative energy balance which cows have to meet from body reserves”; DairyCo 2012b, 2:17). A Spring calving model, by comparison, would involve the cows receiving a less energy-dense diet (i.e. with a higher component of grazed grass) at peak lactation, and therefore requiring supplementary feed.

7.2 Interactions Between Component Categories

Many intensive farmers described their systems by reference to complementarity effects between the technologies and technological configurations described above (**7.1**) and other component categories, including resources (e.g. the physical environment and location, financial resources, knowledge and skills, and labour) and institutions (e.g. beliefs as ‘cognitive rules’).

For many, the choice of farming system had been influenced by characteristics of the physical environment or their financial circumstances. For example, **Farmer M** had limited available land when he first established the farm and suggested that he had borrowed extensively to

⁸⁹ Aligned Farm, interview date: 18/7/16; see Timeline, **Appendix 7E**

finance the business. These conditions, he said, had influenced his decision to establish a production model based around maximising output per cow as opposed to one based around extensive grazing.

Similarly, **Farm F**, which had housed its cows all year round since 1998, having previously offered limited grazing to “low yielders”, revealed evidence of the interaction between the technologies involved with the housed system and the available physical resources. The farm was in Scotland⁹⁰, where the climate was unsuitable for keeping Holstein cows outdoors for prolonged periods. This highlighted the specialised and non-transferable character of Holstein cows and their incompatibility with the prevailing weather conditions (i.e. necessitating housing for extended periods). Further, the farm was on land better suited to producing arable crops than grass, which in turn supported the use of a housed rather than a grazing based system. **Farmer F** returned to the farm from university in 2009 and had been overseeing the dairy operations since 2011, and noted that: “This is the system that I was brought into ... the farm had already been pre-set for this system before I came to it.”

Farmer A also reported that limitations in physical resources had influenced the system used on his farm:

“We've always majored [in] producing our milk in the wintertime. It worked better on this farm. It's not a typical grassland farm ... in the summertime it can dry out. We're on thin chalk ... and you can get into June and you've got virtually no grass... The terrain doesn't lend itself very well [to grazing] either, because we're [on] quite steep [land].”

Farmer I explained that his intensive approach had been influenced by characteristics of the local climate, land and access, which supported and/or constrained the farmer’s knowledge and skills:

“We were never big grazers ... we always struggled to get that right in this area, particularly [as] we've had historical dry summers ... some of our land is quite heavy... access isn't too bad, but we would have to spend quite a lot of money on infrastructure to get access to some of the fields.”

The fact that the farmer was ‘never a big grazer’ meant that the introduction of robots and permanent housing was complementary to his – and his labour force’s – knowledge and skills approach. Moreover, the farmer explained the influence of labour resources upon his decision to introduce milking robots on the farm, which was “fundamentally because of staffing issues ... We were faced with the issue of struggling to find people to milk the cows”.

⁹⁰ The contrast between **Farm F** and **Farm G**, which is also based in Scotland, albeit using an extensive system – see **Chapter 10** – is notable.

Intensive farms provided further examples of complementarity effects resulting from interactions between technologies, resources (in the form of [non-codified] information embodied in the knowledge and skills of actors, i.e. the labour force), and institutions (i.e. actors' beliefs about the 'right' way to farm). Investment and learning effects associated with these components and interactions were also evident.

For **Farm M**, operating an intensive system had accompanied the development of a clearly defined body of knowledge and skills amongst the farmer and his labour force, which in turn supported (and was supported by) his beliefs about the 'right' way to produce milk, or how he framed dairy farming problems and solutions. These skills and beliefs further supported (and were supported by) the continued use of these technologies. There was evidence that the strength of these bilateral complementarity and learning effects had served to inhibit moves to alternative approaches and/or constrain system reproduction within clearly defined boundaries (see further 7.4):

"... I've got three staff, two have been here over 20 years and I'm keen to keep them happy ... My main herdsman in particular has always been focused, like I have, on milking as few cows possible and getting as much milk as possible out of them, rather than doubling the cow numbers and getting half as much production. He might up and leave if I went for a major change."

There was evidence that the system used by **Farm F** was also underpinned by (interrelated) knowledge and beliefs about the 'right' way to farm. Changes in (tacit) knowledge and skills (through the loss of "a good herdsman") had resulted in the introduction of thrice daily milking (see above 7.1). Moreover, the farmer had developed his own knowledge and associated beliefs about dairy farming while on a work experience placement in the United States. The technological configurations on the farm therefore supported (and were supported by) these beliefs (a strong, bilateral complementarity):

*"[When I visited to the US] they set me up on a farm that was milking 1,000 cows, farming exactly the same acreage [as us], in New York state ... and **that was when I was given my dairy education** ... they look after cows really well there... I was working in one of the top 20 herds in New York State. So these guys ... would get together and **really** benchmark. I probably learned a lot about efficiencies from those guys. Everything is monitored. I learned to measure everything, whether it's cow health, foot health ... The first change [I made] was to three times a day [milking]. I did that within about six weeks of coming home." [emphasis added]*

Based on these beliefs, **Farmer F** had voluntarily joined a local benchmarking group and, he said, had implemented "loads of things" as a result of his involvement with that group; a clear co-ordination effect. Bilateral complementarities were also in evidence between the farmer's beliefs regarding benchmarking and those of the milk buyer, Tesco. In this case, the similarity

between the farmer and supermarket's frames implied a process of collective stabilisation and closure of these frames (see further, below 7.3.3.2)

The farmer's beliefs about the benefits of his system, in terms of cow health and welfare, also appeared to provide a means of defending his approach in the face of growing public scrutiny of indoor-housed systems:

"The public probably perceive their milk coming from grass as opposed to this sort of scenario. There was a thing on [television] three or four months ago ... all about dairying ... I was on the Tesco website about a week after ... people were really shocked about the intensive system ... but unfortunately, the guy who was on the intensive system ... wasn't given enough time to tell them just how healthy his herd was ... I've been down there and he milks seventeen hundred cows and he does a hell of a good job of it, and that was the part that needed to be put over ... not that [the cow] needs to be standing in a wet field ... I mean, they only take videos of cows on a sunny day, but I mean up here we just can't do that."

Farmer O explained how his approach to housing and milking had been influenced by knowledge and beliefs acquired during a visit to the Netherlands, which therefore had influenced his mindset. Given that the Netherlands was, at the time "well advanced" of the UK in the use of milking robots, expectation and co-ordination effects were also at play in this case:

*"We went to Holland on a study tour and looked at robots over there, because they were well advanced [compared] to what they are over here ... And that's where I came across the slatted floors and the slurry cellars ... So **we changed the whole idea of what we were going to do** and went from having a parlour with a slurry lagoon to having just one shed with a cellar underneath and slats on top and just putting robots along one side of it. **It made so much more sense.**" [emphasis added]*

Significantly, learning effects on these farms were not restricted to knowledge embedded in human actors (farmers and the labour force) but also included specialised and non-transferable stocks of knowledge embedded within the cattle. **Farmer I** (see 7.1, above) suggested that he was constrained from moving from a fully housed system to a grazing based system not only by the investment effects associated with milking robots, but also due to the fact that grazing is "a learned process". Just as "some cows do struggle to become robotic cows because of ... their temperament" (see above, 7.1), equally:

"You train your animal at a young age as a young heifer calf to go out and graze ... and it's a learned process to actually go and graze in the field."

Similarly, **Farmer O**, highlighted the challenge of moving from milking robots to other milking methods. He recounted the experience of a neighbouring farmer whose robots had broken down:

*"They were having to take their cows to the neighbouring farm to milk them through their parlour... and it's chaos... **You** try and put a herd of cows through a herringbone parlour that haven't been through one in four years or so."*

7.3 The Influence of Buyer Power

This section considers the influence of buyer power – working through or against the positive feedback mechanisms already identified – upon the patterns of change outlined above. It is structured according to buyer demands relating to:

- Security of supply (7.3.1)
- Product characteristics⁹¹ (7.3.2)
- Production characteristics (7.3.3)

Within each of these sections the analysis considers how buyers sought to achieve compliance with these demands (i.e. conditions of value chain governance, including sanctions and trust).

Perhaps unsurprisingly, the influence of buyer demands upon technological change in intensive farms was most evident when buyer demands corresponded closely with farms' progress towards established goals, namely to maximise yield per cow and/or robot (i.e. when they worked 'through' positive feedbacks). In these cases, buyer demands had the effect of influencing farms to further intensify and/or expand production (i.e. to increase rates of change within the cluster).

When buyer demands did not correspond closely with farms' progress towards established goals (i.e. when they worked 'against' positive feedbacks), the presence of strong sanctions and conditions of high trust (continuity, reliability and predictability in the operation of the value chain; see 5.2.6) was essential to enabling buyers to influence farms. Such demands often served to limit or arrest farms' intensification and/or expansion, although it appeared that farms selected approaches to comply with these demands that minimised the disruption to their established systems. Moreover, and again unsurprisingly, the successful influence of such buyer demands appeared to be related to the depth of changes that these demands necessitated. Demands necessitating 'deep' changes (i.e. changes involving farms' 'core' activities) appeared to require the support of strong sanctions and trust. The strength of sanctions and trust in value chains was dependent to some extent on the presence of weaker sanctions and lower conditions of trust across the wider sector

⁹¹ NB: The farm visits provided no evidence of farmers responding (or not) to food hygiene and safety standards above those required by statutory minima, hence the following discussion does not include a section dedicated to these.

Finally, there was clear evidence of expectation and co-ordination effects resulting from benchmarking, with such effects influencing both aligned farmers (directly) and non-aligned farmers (indirectly).

7.3.1 Security of Supply

This section is structured according to the following sanctions used by buyers in order to influence farms (see above, 5.2.6):

- **Base prices for milk**
- **Bonuses** for increased production and **penalties** for underproduction
- **A / B pricing**
- **Seasonality payments**

7.3.1.1 Base Prices for Milk

It was notable that intensive farms had frequently responded to high base milk prices (i.e. positive sanctions indicating buyer demand for milk) by further intensifying and/or expanding production. In these examples, there was a close correspondence between the buyers' demands and the farms' progress towards established system goals (i.e. maximising output per cow / robot).

For example, immediately following the abolition of the MMB, **Farm O** contracted to supply processor MD Foods. **Farmer O** explained that the milk price that MD Foods paid at the time had encouraged him to intensify production through investment in new feeding technologies:

"MD Foods gave us a good price for our milk. We had a lot of money coming in then, so we were looking at ways of improving our milk yield. In 1996 we bought our first feeder wagon, which improved our yields considerably. We also increased the amount of maize we grew ...[and]... because we had a feeder wagon we could make better use of maize ... milk yields would've probably gone up 1,500 litres ... in a matter of a year."

Farmer I reported a similar response ("when prices were good for milk ... it paid to feed the cows"), as did **Farm M** ("We had a Waitrose contract briefly, which was very nice and a good milk price, and encouraged us to produce more milk per cow").

It was also clear that high base prices presented farms with the incentive and/or opportunity to invest in new technologies, which often, due to investment effects (see above), resulted in the further stabilisation of farms' production systems around an intensive model.

For example, **Farmer O** explained how his decision in 2008 to implement significant investments in milking and housing technologies and infrastructure (see 7.1) had been supported by the milk price (“there was money in the milk at the time, and we thought it was a good time to do it”). 2008 saw a significant upturn in milk prices across the sector, with average UK farmgate prices in January 2008 (excluding bonuses) at 25.82p, compared with 5-year rolling averages at the time of 18.93p (excluding bonuses).⁹² The farm had an ageing milking parlour and housing that no longer suited its intensity of production (“our buildings were coming to the end ... they were built for little old Friesian cows and our cubicles were too small ... cows were finding it difficult to lie in them”). Their replacement with milking robots and the accompanying move to year round housing (with cubicles that suited the cows) served to further stabilise and intensify the production model.

Farmer F suggested that the high milk price that he had received under his aligned contract to supply Tesco (through Muller) – and continuity, reliability and predictability associated with this – had enabled him to expand and intensify his system. Indeed, he suggested that his system might not have been sustainable had he been receiving the kind of prices that many non-aligned farmers were being paid at the time. On the date of the interview⁹³, the average price received by farmers on **Farm F’s** Tesco (Muller) contract was 28.55ppl. By comparison, many non-aligned farmers⁹⁴ were receiving as little as 17.75ppl. The farmer suggested that: “... at minus ten pence it would be nigh on impossible [to run a place like this] ... there would be only so long you could sustain it for ... I would heavily think about keeping the cows... I would have to have a complete reshuffle on what I’m doing.”

Significantly, **Farmer F** suggested that the stability of the milk price was key to enabling him to invest in expanding and intensifying his system, and that this was a common experience amongst aligned farmers:

“... it offers stability, so ... we can work at buying things to improve our herd because we know where we are [and] we don’t have volatility [in the milk price] ... when I’ve been around some of the other Tesco herds, the majority of them I see have used that money correctly to build systems that can produce a healthier litre.”

⁹² <https://dairy.ahdb.org.uk/resources-library/market-information/milk-prices-contracts/uk-farmgate-milk-prices/>

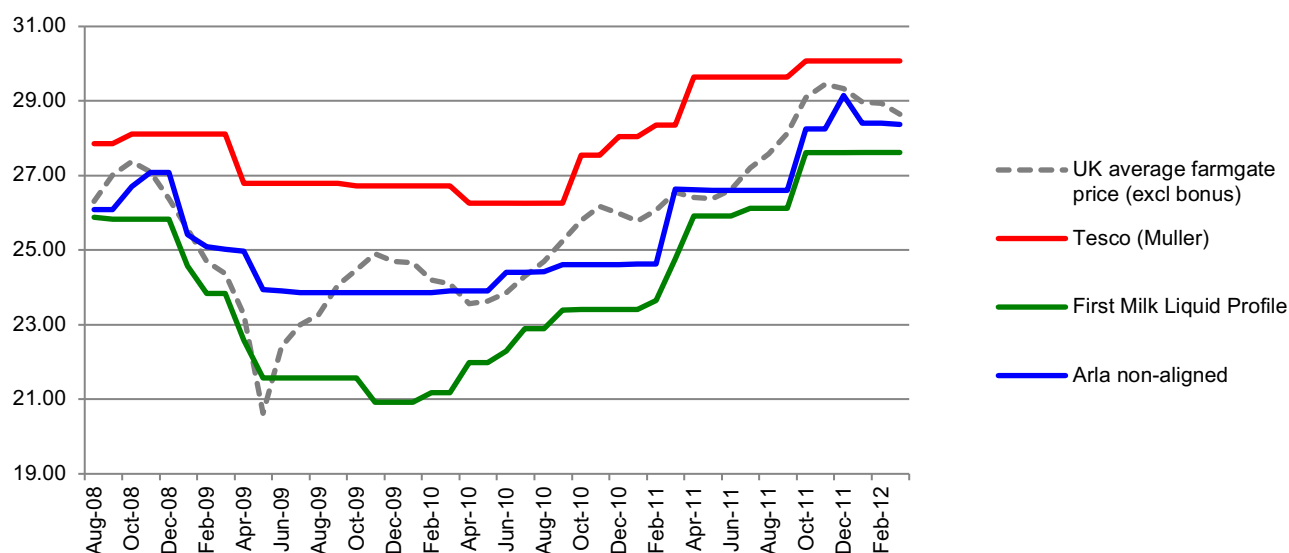
⁹³ 20 July 2016

⁹⁴ UK Arla Farmers Liquid Contract, <https://dairy.ahdb.org.uk/resources-library/market-information/milk-prices-contracts/league-table-new-profile/>

The high, stable price received by **Farmer F** under the Tesco (Muller) contract is illustrated by comparing monthly average milk prices received under the Tesco (Muller) contract against prices received under the standard non-aligned contracts of two major processors (“First Milk Liquid Profile” and “Arla Non-Aligned”; see **Figure 7a**).

Over a 44-month period between August 2008 and March 2012, the Tesco contract paid an average of 27.94ppl, compared with 24.04ppl and 25.5ppl paid under the First Milk and Arla contracts, respectively. Moreover, over the same period, the Tesco price changed 9 times (or every 4.89 months) compared with 17 times (or every 2.59 months) and 23 times (or every 1.91 months) under the First Milk and Arla contracts, respectively. As well as changing less frequently, the amount by which the price changed was also smaller: the variance in the Tesco price over the period was 1.84ppl, compared with 5.08ppl (First Milk) and 2.61ppl (Arla), demonstrating its greater stability. This high, stable price – and the investments that it enabled – is evidence of higher conditions of trust within the Tesco value chain compared with non-aligned value chains. Within such conditions, buyers may be better able to influence changes at the farm level.

Figure 7a: Aligned vs Non-aligned Milk Prices and Volatility



Source: Author (adapted from AHDB data⁹⁵)

⁹⁵ <https://dairy.ahdb.org.uk/resources-library/market-information/milk-prices-contracts/league-table-new-profile/>; <https://dairy.ahdb.org.uk/resources-library/market-information/milk-prices-contracts/uk-farmgate-milk-prices/>

In the above examples, when milk prices were high, there was a clear correspondence between buyers' demands and farms' progress towards established system goals (i.e. buyers' demands were working *through* existing positive feedbacks). However, the analysis also revealed examples in which buyers' demands, expressed through base prices, did *not* correspond with farms' progress towards established goals (i.e. where low prices reflected demand for reduced farm output) and where such demands had successfully influenced farms despite working against the positive feedbacks noted above (7.1 – 7.2).

Farmer A, for example, explained that, although his current system had the potential to be more intensive than it currently was (in terms of stocking rate), low milk prices were limiting investment and expansion (i.e. holding back progress towards further intensification):

"... We've got a plan ... but we're not doing it at the moment because of the milk price⁹⁶ ... to put up a pair of buildings that will enable us to expand the herd and improve our facilities ... to increase the herd size by about 50 percent ... We feel we've got enough capacity with the milking at the moment for 300 cows... But ... we've got to see some improvement to the milk price [before] ... we can think about doing that..."

Elsewhere, as outlined above (7.1), **Farm M** appeared to have experienced diminishing returns to further intensification, which were redirecting technological search and selection towards the pursuit of improved feed efficiency. Low milk prices also appeared to be focusing **Farmer M's** attention in this direction, serving to arrest the process and/or rate of intensification on this farm:

"I've just bought another hundred and fifty acres ... it's an opportunity to look at the what we're doing and whether there is a less intensive way of doing it... with the way the milk price is at the moment."

The farm had increased the home grown forage component in the cows' diets and reduced the amount of purchased concentrate feed.

Similarly, **Farm I** had recently invested in a 'zero-grazing' machine⁹⁷ as a means of reducing feed input prices⁹⁸ in response to low milk prices. This might be characterised as a technological

⁹⁶ NB: **Farm A** supplies Tesco, through Arla, but is no longer paid the Tesco price directly because he opted to become a member of the Arla co-operative. This means that Tesco pays the agreed cost of production price directly into the Arla members' pool, with **Farm A** receiving the standard Arla price, which was, on the date of the interview 17.45ppl, plus a premium; <https://dairy.ahdb.org.uk/resources-library/market-information/milk-prices-contracts/league-table-new-profile/>

⁹⁷ A machine that enables fresh grass to be mown and carried, in bulk, to housed cows.

⁹⁸ Interestingly, the farmer had been less open to considering similar measures when advised to by a previous buyer, with whom relations (trust) had become strained (see **below 7.4**).

change within the boundaries defined by the existing system, resulting from the investment effects associated with the specialised and non-transferable nature of milking robots (Dosi 1988, p.226-7). The prior introduction of milking robots had prevented the farm from achieving similar results (i.e. reducing feed input costs) by using other means (such as, for example, grazing), prompting the implementation of zero-grazing in response to this:

“This year the price of the milk has crashed and we are obviously looking at different ways of doing things and one option is to get more from grazed grass ... we’ve looked into it and we just felt that it’s going to be hard to graze efficiently with robots ... To actually get the cows in and out of the shed ... hence [we have implemented] zero-grazing”.

7.3.1.2 Bonuses for overproduction

Although high base prices (above) may be interpreted (broadly) as a buyer demand for increased volume, bonuses for overproduction provide a more explicit and precise mechanism aimed at achieving the same goal. **Farmer O** explained the influence of such bonuses upon his system, and the powerful incentive that they presented to increase production output:

***Farmer O:** “If you go back to when we put that robot in in 2014 ... back then if we produced 1% more than what we did the year before then we got an extra 0.5ppl for the whole year on all the milk produced ... and if you produced more than 5% than you did the year before then you got an extra penny on the whole production. Now, we were producing 2 million litres a year, so it came to a lot of money.”*

This annual bonus arrangement – in conjunction with a seasonality bonus scheme (see below 7.3.1.5) had influenced the farmer to expand production through investing in a fourth milking robot.

Shortly before the fieldwork was conducted, Tesco had introduced a scheme⁹⁹ to reward its producers with volume bonuses, based on their performance against a range of criteria (discussed below, 7.3.3.1).

7.3.1.3 A/B pricing

Although low base prices (above) may be interpreted (broadly) as a buyer demand for reduced volume, A/B pricing provides a more explicit and precise mechanism aimed at achieving the same goal. Because intensive systems are centred on maximising output per cow, and – through further intensification – will tend towards increased output over time, A/B pricing runs broadly in opposition to the positive feedback effects associated with intensive systems.

⁹⁹ 1 February 2016; <https://dairy.ahdb.org.uk/news/news-articles/november-2015/tesco-maintains-milk-price-link-to-cost-tracker/>

In the cases analysed, where buyers had imposed A/B pricing, there was some evidence of intensive farms responding to such demands by implementing changes within the established boundaries of the system, with the feedback effects discussed already (7.1 – 7.2) appearing to restrict the implementation of more radical changes (i.e. extensification). For example, **Farmer M's** current buyer had introduced A/B pricing (see **Appendix 7F**) in April 2015:

"The first 6,900 litres that we produce we get paid the flat rate basket price for ... which is 21ppl ... and anything over that we get what is called [an] 'open market price' which is actually the spot price, which was 13.7ppl last month."

In response to this strong disincentive against production, the farmer had decided to cull 40 cows ("because they were producing B litres milk... and we were just buying feed to feed them"). Technically, the farmer *could* have sought to reduce total farm output using a range of possible approaches, including reverting to twice daily milking or substantially reducing feed inputs (and associated costs) per cow. The approach he selected, however – culling 40 cows from the herd while maintaining output *per cow* – demonstrates the action and strength of the complementarity and investment effects outlined above (7.1), which served to preserve a model centred on maximising output per cow, and which was strongly underpinned by the farmers' beliefs about the 'right' way to farm. Put differently, the farmer had opted for minimal disruption ('shallow' changes) to the system and the buyer's demands had influenced the *scale* of operations rather than the *intensity* of technological inputs on this farm.

Within aligned value chains buyers impose limits with regard to the number of 'core' or 'base' litres for which farmers may receive the premium, aligned milk price, with farmers being paid the standard processor price for additional litres supplied above that level (see **Appendix 7G**).¹⁰⁰ The influence of such measures on farms was also evident, despite the fact that the sanctioning effect of supermarket-imposed volume limits may be relatively less punitive than the sanctioning effect of A/B pricing within non-aligned contracts.¹⁰¹ According to **Farmer O**:

"If you are supplying Tesco ... probably ... 70% of your milk will go to Tesco, and the other 30% will be paid at the standard Muller price ... [the proportion that receives the Muller price is] the percentage of your production for the month over the base (which is worked out by the average of [your output for] the same month last year and the year before) ... So ... if you have

¹⁰⁰ Although this is not referred to as 'A/B pricing' within the industry, it serves the same purpose, imposing a financial penalty for production above certain specified limits.

¹⁰¹ For example, in April 2016 the price received by a Tesco (Muller) farmer for additional litres above the specified limits would have been 20.36ppl, compared with the spot price of 13.7ppl received for 'B' litres under some non-aligned A/B contracts (see above); <http://www.mynewsdesk.com/uk/muller-wiseman/pressreleases/muller-confirms-april-milk-price-reduction-due-to-continued-volatility-1329082>.

*expanded a lot in the last two years you'll get a lower percentage than somebody who hasn't expanded. So **it's not encouraging you to expand.***" [emphasis added]

In other words, supermarkets' efforts to limit volumes encouraged aligned farmers not to expand, whereas processors' efforts to limit volumes encouraged non-aligned farmers to scale back production.

7.3.1.4 Seasonality Adjustments

Only one out of the five intensive farms analysed had been influenced to change their calving pattern by seasonality payments. **Farmer A** (see above 7.1) revealed that buyer demands had influenced his decision to change from operating two calving blocks (Spring and Autumn) to a single Autumn block:

"With our particular contract, there are penalties for producing more milk in the Spring than you do in the winter time. So it does make sense for us ... from that point of view, to produce more milk in the winter." (See **Appendix 7H**)

Farmer O recalled how his milk buyer's previous seasonality bonus scheme had influenced his purchase of a fourth milking robot, expanding the production system (see also 7.3.1.2, above):

"... if you produced more milk in the months from October to February ... they paid an extra 6p a litre ... just for those extra litres. We sat down and worked it out: 'If we put this robot in, it was worth something like an extra £50,000 in one year' ... which would pay for the robot, because I'd bought a second hand one."

Farms O and **F**, supplying supermarkets, had both operated all year calving models since the beginning of the study period. All year calving corresponded well with their buyers' demands for a level year-round supply of milk, and therefore required no changes to their system. Indeed, the close correspondence between Tesco's scheme for seasonality payments, and **Farm O's** level production profile (which its housed / robot system both necessitated and facilitated, see 7.1.2), was particularly evident:

*"It used to be that if you could produce milk within plus or minus 15% you stayed on a single price right through the year... which is what we've done over the last five or six years ... we haven't had a seasonality payment, because we could keep our milk production within those parameters ... But now they've got a really, really complicated seasonality system, which I still don't really understand... but basically if you can keep within five or ten percent of an average, then you don't have any seasonality, **but if you do vary you do incur seasonality [penalties] and the more you vary the more the seasonality [penalty] is.**"* [emphasis added]

The refusal of **Farms M** and **I** to comply with buyer demands for changes in their production profile is outlined below (7.4.1).

7.3.2 Product Characteristics

Evidence of buyers influencing product characteristics was limited to the use of sanctions to encourage changes in the constituent content of milk. Whereas demands relating to volume and profile (7.3.1) had required quite fundamental ('deep') changes to production systems (e.g. to calving pattern), changes to constituent content were generally not 'deep' but could be achieved, for example, through adjustments to feed inputs.

7.3.2.1 Sanctions: Bonuses / Penalties for Constituents

For **Farmer M**, buyer demands in the immediate aftermath of the abolition of the Milk Marketing Board (MMB) were complementary to his intensive approach, and strongly influenced his subsequent use of breeding technologies:

"I remember when Unigate took over from the Milk Marketing Board ... the Unigate bloke stood up and said 'there's no market for saturated fats, what we want is volume', so we bred the cows very much for volume rather than butterfat yield, which we've slightly come to regret later on, but it stood us in good stead. In those days we were using bulls that were predicted to transmit a thousand litres more than their daughters, so yields went up quite fast ... and solids [constituents] didn't follow because that was what we were told we didn't need."

Farm O switched processors numerous times between 1994 and 2016, with different buyers making different demands regarding the constituent content of the milk. **Farmer O** explained how this had influenced the farm system, largely involving changes to the composition of the ration fed to the cows, which it appears could be readily accommodated without requiring fundamental changes to the existing system:

*"MD Foods gave us a good price for our milk. We had a lot of money coming in then, so we were looking at ways of improving our milk yield... We then went to Horlicks Creamery, which was a cheese factory. They wanted high constituents in the milk so we then started feeding things like caustic wheat, which would improve milk proteins... We then went to Westbury Foods ... which was [a] liquid milk [contract]... so I think we went for then producing more volume ... and cut the quality back, so we cut a lot of the caustic wheat and probably gave them a more high-protein diet... we ended up at Cricketer cheese factory ... so then we went back to producing high protein and high butterfat milk... so the diet changed again, but I think we managed to change it without losing too much volume ... then I went to Wiseman, which is a liquid contract [see **Appendix 7I**], which suited me much better... so then we could produce as much low protein and low butterfat milk as we wanted!"*

The farm was able to respond to these changing buyer demands, without altering its overall intensive production approach, in spite of the obstacles presented by the use of milking robots:

"[When we introduced the robots] were still supplying Cricketer Farms, which was obviously a butterfat / protein based payment. But when we changed to the robots there are certain things you have to do to make the robot system work. And you cannot feed a high starch TMR, which is what we were feeding to get the high milk protein [see above 7.1]... the biggest problem with robots... [is that] it is very difficult to produce high protein milk"

7.3.3 Production Characteristics

This section considers buyer's efforts to influence the cost of production and standards of animal welfare and environmental performance.

7.3.3.1 The Cost of Production (and The Power to Exclude)

The milk price paid to farmers within aligned value chains is frequently calculated by reference to the average cost of production of the pool of producers supplying the supermarket. For example, farmers within the producer pool supplying Tesco (the 'Tesco Sustainable Dairy Group' or 'TSDG') received a price based upon the cost of production, through Tesco's 'Cost Tracker' scheme (see **Appendix 7J**), under which an independent consultancy – Promar – calculated the milk price based on the average cost of production of all members of the TSDG.¹⁰² The use of this pricing mechanism indicates Tesco's goal of encouraging farmers to reduce their production costs and/or improve production efficiency (for example, through reducing the fixed and variable costs that form the basis of the cost of production calculation).

Further goals were revealed by Tesco's 2015 review of its supplier base, following which the supermarket resolved to source all of its milk from within its aligned pool (in the words of **Farmer O**: "Now what they want is that all their milk comes from full Tesco farms. So ... now ... they've got enough farms that will match their highest [level of] demand"). As a result of the review, Tesco introduced a 'balanced scorecard' to measure the performance of farms in terms of 'quality', 'value', 'innovation' and 'service', parameters that serve to outline – in broad terms – the 'problems and solutions' that the supermarket associated with dairy farming. The top 5% of producers, assessed using this scorecard system, would be rewarded with "an additional 100,000 litres to produce within their TSDG contract", with this extra volume being made available as a result of "retirements or through the performance review process".¹⁰³ Moreover, "the bottom 5% of farmers will be given a notice period of 6 months".¹⁰⁴

¹⁰² <https://www.tescopl.com/news/news-releases/2016/tesco-continues-to-pay-a-market-leading-price-to-dairy-farmers-for-their-fresh-milk/>

¹⁰³ <https://dairy.ahdb.org.uk/news/news-articles/november-2015/tesco-maintains-milk-price-link-to-cost-tracker/>

¹⁰⁴ *ibid.*

Given that the review had only recently been completed at the time the fieldwork was conducted, the farmers interviewed appeared uncertain as to its influence on their systems. For example, when asked whether he felt that Tesco was expecting farmers to constantly lower their production costs **Farmer F** replied that:

"Tesco are really driven by health ... and carbon footprint. And ... they try and put that across to their customers as much as possible. Health is a big driver."

Farmer A, on the other hand, explained that:

"I think all [Tesco are] trying to do ... is encourage us to produce our milk as cheaply as possible. And I think that ... one of the ways that they're trying to help us – and help themselves, obviously, too – is to point to where the feed might be cheaper, or what sort of feeds are cheaper..."

In this sense, Tesco's demands for improved production efficiencies appeared to correspond with intensive farms' progress towards established goals. In particular, Tesco's demands were consistent with many of the 'reverse salients' associated with intensive farm systems, such as those that had emerged as farmers were experiencing decreasing returns to intensification (see above 7.1).

Moreover, it was also apparent that the practice of benchmarking aligned farms according to production costs was giving rise to expectation and co-ordination effects. When asked whether Tesco had instructed farms to emulate the production approaches of the 'top performing' farms with a view to driving down production costs, **Farmer A** replied:

"Not that I'm aware of ... But, I suppose we were all sort of doing that to some extent anyway. So if you ... hear of farms performing particularly well, then you ... look at their system, if you have the opportunity, and see how they're doing it. So I suppose we're doing that anyway. And most of us, we use a nutritionist and somebody who can advise... and obviously, they're looking at other farms as well, so they can bring that information to you..."

Furthermore, it was also evident that the supermarket practice of collecting of data for the purpose of benchmarking (both accounts data and data on other performance metrics, such as animal health and welfare) had a more *pervasive* effect, influencing farms both inside and *outside* of the supplier pool. For example, **Farmer O**, who had been awarded a Tesco contract just months before the date of the interview, explained that meeting Tesco's demands for production characteristics with regard to animal welfare (see below 7.3.3.2) had required no fundamental changes to his system, because:

"We were there already because we wanted a Tesco contract, so we were trying our best to be what they wanted anyway." [emphasis added]

Tesco farmers appeared to be supportive of benchmarking, in spite of Tesco's review of the TSDG and the threat that the "bottom 5%" of Tesco farms would be given notice while the worst performing farms would be subject to more rigorous modes of inspection than other Tesco suppliers. According to **Farmer O**:

*"Apparently we will get a visit [from Tesco, to perform an audit] at any time, but at least once a year.... And if you're at the bottom of the scale you'll get more visits, and if you're at the top of the scale you'll get less visits ... it's very competitive... some farmers don't like that, **but if some people are prepared to put in the effort to do better, why shouldn't they be rewarded?**" [emphasis added]*

Indeed, there was some evidence that the transparency of the cost of production pricing formula had influenced farmers' mindsets, in particular with regard to their perspectives on the 'fairness' of such pricing mechanisms (**Farmer F**: "it's a pretty fair process ... they get all this information and they put us on a cost of production contract"). However, it does seem probable that farmers' willingness to concede to supermarkets' data collection and benchmarking requirements is closely related to the presence of positive sanctions in the form of a high, stable milk price (see above, 7.3.1.1). As **Farmer O** suggested:

"People are very reluctant to give their figures to Tesco ... but there is no other contract out there that will match it ... because they have put in a decent profit margin. They [others] think it's just a cost of production [price], but there is a profit margin in there as well, which is a good profit margin. And no other contract will give you that."

Moreover, the scale of the negative sanction associated with losing a supermarket contract (i.e. the supermarket's 'power to exclude', see 5.2.6) should not be overlooked. According to **Farmer O**:

*"There was a period ... where the standard milk price was actually higher than the aligned Tesco or Sainsbury's price ... and there were some farmers that were so upset by this that they went out and changed [to a non-aligned contract]! [laughs] ... And Tesco's will tell you: '**if you leave, we won't have you back!**'" [emphasis added]*

Significantly, the Cost Tracker scheme had initially involved the voluntary submission of accounts data by farmers, in exchange for a 0.5ppl bonus. The 2015 review of the TSDG made the submission of accounts data compulsory (for example, **Farm A** had not initially signed up for the 0.5ppl bonus for supplying accounts data but had been required to from February 2017). This may represent a shift in the governance of the Tesco value chain.

7.3.3.2 Animal Welfare and Environmental Performance

Both aligned and non-aligned contracts¹⁰⁵ required farms to adhere to certain standards with regard to animal welfare and environmental performance.

The farm interviews implied that such demands typically required ‘shallow’ changes to farms’ systems. For example, when he was awarded a Tesco contract, **Farmer A** was already undertaking locomotion scoring, body condition scoring, antibiotics use, and monthly milk recording (for yields, fats, proteins for individual cows), in accordance with Tesco’s demands. He reported that his system presented no obstacles to complying with Tesco’s further demands for abrasion scoring, lesion scoring, cleanliness scoring and the submission of accounts data.

Similarly, **Farmer O** stated that he was willing and able to comply with Tesco’s demands (see above 7.3.3.1):

“We ... have to do mobility scoring, which is not a big problem ... and we’ve had to change some of the antibiotics we’ve used, because we were using the third generation antibiotics for mastitis... no big problem with that.”

For **Farmer F**, Tesco’s demands for data collection and its approach to benchmarking corresponded closely with the farmer’s own beliefs about the value of data collection and monitoring, acquired during his time in the US (see above, 7.2). The farm had implemented monitoring (including mobility scoring, antibiotics use, and mastitis levels) at the request of the buyer, but these changes were consistent with the farmer’s existing approach, and therefore did not require ‘deep’ changes to the system):

“Tesco want to know where their milk is coming from. It isn’t much work. They just want to know what it is that they are buying. And they want to be able to tell their customers what they are buying too. So it’s not a lot of hassle. And most of the information that we give them we should be using ourselves ... even just getting you to count your antibiotics usage every month, that’s something you should be doing anyway, but you don’t probably if you’re not on a Tesco contract.”

In such examples, it was significant that both the farmer and the supermarket appeared to frame the problems and solutions of dairy farming in similar terms. In this sense, the practice of benchmarking provided a framework within which buyers’ demands both influenced – and were influenced by – farmers’ production approaches (i.e. not only because supermarkets are not themselves users of technology meaning that their ‘frames’ are informed by farmers’ use of the technology but, moreover, because examples of ‘best practice’ that buyers hoped to spread

¹⁰⁵ e.g. “ArlaGarden” assurance scheme within Arla (non-aligned) contracts;
<https://www.arla.com/company/responsibility/farm-quality/arlagarden/>

across producer pools were developed by the best-performing farms. It was also significant that farms, as a result of being benchmarked, were framing the issue of benchmarking in terms of the value or benefits that it presented to them (see further, 9.3.3.1).

Elsewhere, there was clear evidence of the conditions of trust within aligned value chains, in which supermarkets provided support and extension services that served to influence the reproduction of farm systems. **Farmer A** explained:

"I think [Tesco are] trying to aid us to improve cow welfare. So they've done workshops ... on ... dry cow therapy ... locomotion ... lameness, mastitis, calf rearing, things like that. We've definitely learned things [from those workshops] and put things in place to help us improve our management."

7.4 When Buyer Power Fails to Influence Technological Change

Broadly, buyer power failed to influence technological change in farms where sanctions were weak and/or there was a lack of trust within the value chain. This was exacerbated where buyer demands required deep changes to farms' systems.

7.4.1 Security of Supply

Farm M has followed an intensive trajectory, operating an Autumn-calving model, since the outset of the study period (see 7.1). Although the farm provided examples of buyer demands influencing processes of change, **Farmer M** also reported that it had *switched* milk buyers in response to buyer demands for system change. In 2008 the farmer made the decision to switch from supplying Dairy Crest to supplying Freshways after Dairy Crest had demanded a level year round production profile from its farmers.

Although a move to all year calving would be compatible with an intensive trajectory (and might be regarded as accelerating development along that trajectory, being generally associated with increased housing period and higher feed inputs per cow) it would nevertheless require quite deep changes affecting this farm's core activities (namely, a move from autumn calving to all year calving, which would alter long-established working practices and processes on the farm, and require the development of new skills). Therefore, in this example, investment and learning effects appeared to play an important role in countering buyer influence:

"I left Dairy Crest because ... they wanted level production and they were pushing quite hard for all year calving ... it wasn't what I wanted to do ... All my working life we've been an autumn calving herd, so it was what I was used to."

These investment and learning effects were also associated with ‘beliefs’ about the right way to farm. Having autumn-calved for over thirty years, the farmer explained:

“I think it works very well... as much as anything [for] the youngstock rearing ... it’s one hell of an advantage... I don’t think people realise what an advantage it is over having replacements born all year round. I’ve always felt we’ve got the best results by being able to concentrate on one thing at a time.”

Moreover, it appears that levels of trust (seemingly related to knowledge and associated beliefs) within the value chain were low, and that this may have further hindered the buyer’s ability to influence the farmer:

“When we gave our notice in, a senior director [at] Dairy Crest, came to see us to try to convince us to stay ... and I was very unimpressed with his knowledge of dairy farming ... he pretty much convinced me to leave Dairy Crest ... he just didn’t understand about how milk production worked.”

By contrast, the farmer described stronger conditions of trust between himself and his new buyer:

“Freshways are a relatively small company... a third of the size [of Dairy Crest] ... but they claim to be the biggest family owned or independent [processor] ... we spoke directly to the Managing Director, he took us around the factory, showed us how everything worked ... I felt much more comfortable with that sort of family structure rather than Dairy Crest executives who are really looking at numbers on a piece of paper and don’t really understand what they are buying or what they are doing... I’ve got a good enough relationship with [the Managing Director] that I can ring him up and ask him what’s going on ... but he is quite open, really ... he’ll tell you anything: what his costs of processing are, what his markets are and suchlike.”

The influence of sanctions upon the farmer’s decision making was also apparent. The availability of an alternative buyer (Freshways) – which paid a good milk price – meant that there was no negative sanction associated with leaving Dairy Crest. Moreover, the buyers’ demands contained within the Freshways contract corresponded closely with farms’ progress towards its established goals:

“It’s a very simple white water contract, [which] suits our three times a day system, because there is no incentive for high solids ... that suits our high input-low solids [milk] ... [it] actually suits us very well because we produce most of our milk over the winter and ... we’re producing quite a lot of milk on some of the best prices in the country because we’ve had no penalties for seasonality.”

In the case of **Farm I**, the failure of buyer power to influence the farm’s calving pattern, through seasonality payments, demonstrated the strength of complementarity effects that had created by the introduction of milking robots (see above 7.1) relative to weak positive sanctions:

"We're all year round calving... we always were really, before the robots, but with the robots installed, [it helps] just to keep a continual, level supply of milk. And our milk supplier [buyer], whilst they still do a seasonality payment thing ... they are a liquid supplier ... we don't really seem to get any real benefit from doing that particularly."

Much stronger positive sanctions (in the form of a bigger seasonality bonus) and corresponding negative sanctions (in the form of the threat of loss of contract) would be required in order to ensure compliance with these demands.

7.4.2 Production characteristics

Farmer I recalled an unsuccessful attempt by a former buyer – First Milk – to influence his production approach. The buyer had established a discussion group for its farmers, which was attended by a First Milk representative who attempted to influence the farmers to focus on reducing their production costs:

"I remember one particular meeting, he stood and did a bit of a slide presentation to try and tell us [that farmgate price] isn't the main driver of profitability... [that] it actually comes down to cost of production, and keeping that as low as possible... but it was a little bit galling to hear him say that when we knew there were people up the road getting quite a bit more for their [milk] ... if your neighbour up the road producing the same amount of milk was by default getting another 2 or 3ppl on his milk, you know, on a million litres, that's another 20 or 30 thousand pounds [per annum] just like that."

First Milk's unsuccessful attempt to influence the farmer's cost of production in this example may be contrasted against Tesco's successful influence upon farmer production costs (described above, 7.3.3.1). While it was apparent that the presence of powerful positive sanctions (in the form of a high, stable milk price) and negative sanctions (i.e. the threat of losing the contract) may have been instrumental in enabling Tesco to successfully influence the farmers supplying it, the absence of similarly strong positive and negative sanctions in this example may have restricted the buyer's ability to influence the farmer. Put differently, the buyer's inability to influence **Farmer I** appears to be related to the low milk price that the buyer was paying, and the availability of better prices elsewhere (i.e. the opportunity cost associated with losing the contract was low).

Similarly, it was implied that conditions of trust within the aligned value chain (related to / resulting from the high, stable milk price) may have played a role in enabling Tesco to influence its farmers. Such conditions of trust were notably absent within First Milk's value chain, as indicated by the Farmer's history of "frustration" with the buyer. Again, these low conditions of trust appeared to be directly related to the low, volatile price being paid by First Milk. **Farmer I**

switched milk buyer in the middle of 2013, due to longstanding dissatisfaction with the milk price he had been receiving:

"We'd been getting more and more frustrated with First Milk for a number of years... we'd had a look at leaving previously... [but] there was no one interested in taking us on... when we eventually were able to get out, it was a time when people were looking for milk... and we could have easily gone with Arla... you know there was different people we talked to... we ended up going with Cotteswold."

The low, volatile price paid by First Milk price was outlined already above (**Figure 7a**). Over a 44-month period between August 2008 and March 2012 the mean price paid under the First Milk Liquid Profile contract was 24.04ppl, compared with the UK average farmgate price of 25.70ppl. Moreover, the variance¹⁰⁶ of the First Milk price was 5.08ppl, whereas the variance of the UK average farmgate price was 4.10ppl over the same period. Having switched milk buyer, the farmer subsequently focused on reducing production costs.

Farmer O had also switched buyer following demands from his buyer aimed at enforcing a specific production standard that was inconsistent with farmer's beliefs about the right way to farm. The farmer explained that his buyer – Cricketer – a processor that specialised in producing cheese, wanted to prevent its suppliers from using 'Orbeseal' teat sealant, believing that one of the ingredients of Orbeseal – bismuth¹⁰⁷ – caused 'black spot' in mature cheddar. It appeared that complying with this demand would involve a deep change to core activities on the farm:

"Orbeseal is really part of my routine, I can't go without it... I think it is essential for dry cow management ... it's a dry cow management tool, which has I think most vets would tell you has been a revolution in dry cow therapy..."

¹⁰⁶ i.e. the variability of the price around the mean, providing an indication of the volatility of that price

¹⁰⁷ <http://www.broughtonveterinarygroup.co.uk/news/wp-content/uploads/2010/02/2012.10-Newsletter-October-20121.pdf>

Chapter 8:

Technological Change in Extensive Farms

This chapter considers patterns of technological change in extensive farms and the influence of buyer power upon these patterns. The analysis begins with a description of farm socio-technical systems by reference to inputs and outputs and the positive feedbacks and reverse salients associated with the interactions between technologies (8.1) and between technologies and other components (8.2), which serve to highlight farms' progress towards system goals. This is followed by an analysis of the influence of buyer demands, by reference to conditions of value chain governance, upon this progress (8.3), contrasted against instances in which buyer power has been unsuccessful (8.4) in influencing the extent, rate or direction of technological change.

8.1 Interactions Between Technologies

The configurations of technologies used on intensive farms – and the interactions between these technologies – supported progress towards the broad goal of maximising output per cow and/or per milking robot (where these were used; see **Chapter 7**). By contrast the technological configurations used on extensive farms appeared to centre upon maximising the performance (i.e. growth and utilisation) of grass, supporting progress towards the goal of minimising inputs of purchased feed per cow and/or per litre of milk (a further – related – goal being the reduction of labour inputs per cow / litre). Therefore, although interactions between breeding, feeding and housing technologies were pronounced on both extensive and intensive farms, the selection of (and the approach to and intensity of deployment of) these technologies was noticeably different between the two systems.

Chiefly, the use of robust breeds of cattle (as opposed to Holsteins, see 5.1.2 and **Appendix 5C**) – able to withstand a broader range of weather conditions¹⁰⁸ – enabled extensive farms to house their cows for a smaller proportion of the year compared with intensive farms and therefore to graze for a larger proportion of the year, meaning that grass constituted a larger proportion of the cows' diets. Moreover, being more physically robust, the cattle were better able to tolerate the inconsistencies in diet resulting from inevitable variations in grass growth (i.e. in both the volume and nutritional quality of grass) throughout the year, by contrast to the pedigree

¹⁰⁸ "Some breeds are considered to be better at looking after themselves and replacing condition more easily than others, making them better suited to systems involving out-wintering or extended grazing ... deeper-bodied cows with larger rumen capacities [may be] better adapted to high forage grazing systems." (DairyCo 2012b, p.2:26). Related to this, the interactions between technologies and physical resources (i.e. climate) on extensive farms were also distinct from those on intensive farms (see below, 8.2).

Holsteins favoured by intensive farmers, which required a more controlled, consistent diet all year round. There was also evidence of bilateral complementarity effects between the adoption of Spring calving and the use of grazed grass as the primary component of the cows' diets: grass growth is greatest in the Spring, coinciding with the Spring-calved cows' maximum energy requirement.

The lower requirement for housing also appeared to provide extensive farms with greater scope for herd expansion (herd size could be increase without the need for additional housing infrastructure).

Farm P¹⁰⁹ provides some useful examples of the distinctions between extensive systems and more intensive models of production, and of the different interactions between technologies within each system. In 2005 **Farmer P** returned to the family farm and began to extensify production. At that time, the herd had been composed entirely of pedigree Holstein cows, fed a total mixed ration (TMR), achieving yields of approximately 9,000 litres per cow¹¹⁰ (i.e. a similar approach to the farms considered in **Chapter 7**; see also timeline **Appendix 8A**). In 2005 **Farmer P** began crossbreeding the Holsteins with Norwegian Reds and Jerseys, and shifted from all year calving to Spring calving. In 2007 he stopped feeding a TMR in favour of an 'easy feed' approach (see **5.1.2**; **Table 5a**). In 2010 he realised that his use of feed inputs had not advanced fully in line with the other changes made within the system (which had been aimed at reducing inputs per cow), and that this was holding back overall system performance (i.e. a reverse salient had emerged):

"2010 was probably the year we ... said 'we need to fully adapt to the grass based system', because we sort of had one foot in each camp ... we probably got to the point where we were milking sixty percent crossbreds and forty percent Holsteins [but] we were still tailoring the system to the Holsteins ... [and] the crossbreds were getting fat."

Farmer P addressed this through reducing concentrate feed from 3.5 tonnes to 2 tonnes per cow per annum on the date of the interview (which, he suggests, "is [still] pretty heavy for those little cows" but had been necessary "because we didn't have enough silage this year").¹¹¹

¹⁰⁹ Non-aligned farm, interview date: 18/7/14; Timeline **Appendix 8A**

¹¹⁰ Compared with UK average yields in 2005/6 of 7,001 litres per cow per milk year;
<https://dairy.ahdb.org.uk/resources-library/market-information/farming-data/average-milk-yield/>

¹¹¹ Mean compound feeds for the Milkbench sample in 2013 were 1.9 tonnes [1,903kg] for intermediate farms and 1 tonne [1,033kg] for extensive farms

On the date of interview, the cows were being housed for approximately 100 days of the year (and grazed for the remainder), which would have placed the farm within the tenth percentile of the Milkbench dataset for housing period.¹¹² The farmer explained the contribution of the above changes to breeding and feeding technologies towards current milk yields of 7,500 per cow¹¹³:

“About four thousand [litres comes] ... from forage, and the rest you get from concentrate ... [whereas] when we had nine thousand litres a year we probably only got about three thousand litres from forage... the bigger [i.e. Holstein] cows are more efficient at converting concentrate.”

The farmer also summarised the ways in which the crossbred cow complemented the housing and feeding technologies deployed on the farm:

“The difference between our cows and the bigger cow is that they are just not overly affected by bad management ... if we put them in a grass field and there's not enough grass in there, they don't die, they just get hungry ... But ... the pure bred Holsteins are always on the edge, which is why you have a feeder wagon [for feeding a TMR], because you're trying to get as much feed into them [as possible].”

The use of crossbred cattle therefore supported a reduction in other technological inputs, as well as a reduction in labour (“management”) inputs (see further, 8.2).

Additional evidence of breed selection supporting the performance of feeding and housing technologies (with the goal of reducing inputs per cow) was apparent in the case of **Farm G**¹¹⁴, which comprised a herd of 600 Friesian-Jersey crossbred cows in Scotland, yielding 5,000 litres¹¹⁵ per cow.¹¹⁶ The farmer explained the importance of cow breed to his farming model:

“[The cows] go out to grass almost immediately [after calving in February/March] ... if the conditions allow ... And the only condition that will stop us is snow ... The breed of cow is very, very important ... The Holstein wouldn't survive in this type of system.”

¹¹² The mean housing period for farms in the Milkbench dataset (2013) was 31.96 weeks (223.7 days), while for the extensive cluster the figure dropped to 24.56 weeks (171.92 days).

¹¹³ Mean yield for extensive farms in the Milkbench dataset were 6,706 litres

¹¹⁴ Non-aligned farm, interview date: 21/7/16. The farmer had only been operating on the site a little over a year, hence no timeline is provided.

¹¹⁵ Yields of 5,574 litres and below would place the farm in 10th percentile of the Milkbench dataset.

¹¹⁶ Unlike the other farms within this study, **Farm G** had been established relatively recently (December 2014), although the farmer had been in dairy farming for over a decade (“There was zero dairy infrastructure here as it had been a mixed enterprise of beef, sheep and arable”). Complementarity effects were nevertheless in evidence. Moreover, the farmer had over 10 years experience in dairy farming, which provided evidence of investment and learning effects.

In addition to these complementarity effects, investment effects associated with crossbreeding were evident not only from the adaptation and specialisation of the crossbred cow to the extensive system but, moreover, from the length of time required to implement (and by implication reverse) such breeding changes (highlighting the fact that the cows were not readily transferable to a different system). According to the farmers interviewed, the effects of crossbreeding took between three and ten years to become established.

A feature of the extensive farms in the study – related to the breed-feed-housing interactions detailed above – was the apparent ease with which they were able to increase herd size. The low feed and housing inputs on these farms, enabled by the use of crossbred cows, appeared to support such expansion and to allow the farms to achieve a high stocking rate. For example, the changes at **Farm P**, described above, accompanied an increase in herd size from 140 in 2005 to 240 in 2014, resulting in a very high stocking rate of three cows per hectare.¹¹⁷ The farmer explained that, because crossbred cows are smaller than Holsteins, with lower nutritional requirements, “you can keep more of them on less of an area”. The stocking rate at **Farms G** and **K** was two and a half cows per hectare.

Farm K¹¹⁸, which had operated an (increasingly) extensive system throughout the study period, provided further evidence of complementarity effects between breeding, feeding, and housing technologies – these interacting in turn with production cycle – as well as evidence of an expansion in herd size over that period enabled by this configuration of technologies.

When **Farmer K** took charge of the farm in 1994, he inherited a herd of 170 Autumn-calved cows, which were “British Friesian with a fifty per cent ... Holstein influence”. The farmer planned to expand the herd by introducing a block of 60 Spring-calved cows (“so that I could add more cows to the farm without changing the infrastructure [i.e. housing]”). He explained:

“If we were to change [back] to a single Autumn block we would have to reduce cow numbers because I haven’t got enough housing for everybody at once ... With the two blocks, and particularly with the Spring block, when they are outwintered, we actually have the ability to have more cows than we would otherwise have.”

The farmer planned this Spring-calved block to operate as “a *very* low input system ... [based on] grazing with a very small amount of bought feed”. In order to achieve this, he introduced

¹¹⁷ Compared with mean values for the Milkbench dataset of: 2.37 LU/Ha (livestock units per hectare) for the intensive cluster, 1.76 LU/Ha for the intermediate cluster, and 2.09 LU/Ha for the extensive cluster. For whole dataset a stocking rate of 2.47 and over would place the farm in the 80th percentile, while a stocking rate of 2.78 and over would place the farm in the 90th percentile.

¹¹⁸ Aligned farm, interview date: 28/5/16; Timeline **Appendix 8B**

New Zealand Friesian genetics into the herd (i.e. to produce cows that were better suited to a system of minimal housing and extensive grazing). At the time of the interview, the herd contained “predominantly New Zealand genetics, with some Norwegian Red crossbreds”. The farmer explained that the genetic make up of the cows permitted the use of very low feed inputs: “The Autumn calvers just have *just* grazed grass, nothing else ... [while] the Spring calvers have a small quantity of bought feed, a little bit of silage and 23 hours of grazing”.

The ability of crossbred cows to tolerate this type of Spring-calved model provides a contrast to the experience of more intensive farms. For example, **Farmer A** (see above, 7.1) had moved from operating two calving blocks (Spring and Autumn) to a single Autumn block, because his high-yielding Holstein cattle could not meet their peak energy demand within a Spring-calved model without the addition of considerable feed supplementation.

More generally, interactions could be observed on extensive farms between the configurations of breeding, feeding and housing technologies outlined above, and broader technological approaches to fertility and production cycle. Chiefly, a block calving model supports improved fertility through enabling the easier detection of ‘heat’, without the need for additional technological or labour inputs. As **Farmer K** explained:

“On a block-calved system it’s usually pretty easy to find bullers [i.e. cows in oestrous]. On an all year round calving system, if there’s only one cow bulling on a particular afternoon, and she hasn’t got a friend to play with ... it’s quite difficult to see.”

Accordingly, whereas technologies such as heat detection collars were relatively commonplace on intensive farms operating all-year calving models (**Farms I and O**, see **Chapter 7**) – as well as those operating block calving models (**Farms M and A**; **Chapter 7**) – extensive farms favoured comparatively rudimentary (and less expensive) approaches to heat detection, consistent with their focus on reducing input costs. For example, **Farmer G** used what he referred to as “crayons” to identify cows in heat. This involved painting the cows’ tails: where paint was rubbed away this provided evidence of ‘bulling’. Similarly, **Farm K** – after a switch from a block calving model to all-year calving had been “imposed” on the farm, (see below, 8.3) – introduced EstroTECT¹¹⁹ detectors, or “scratchcards” – which worked on the same principle as the “crayons” described above.

In addition to heat detection technologies, and in common with the intensive farms discussed in **Chapter 7**, cow fertility was a priority on extensive farms (although, unlike some intensive

¹¹⁹ <http://estroTECT.com/estroTECT-heat-detector/>

farms, the focus on fertility was not the result of a reverse salient associated with the use of high yielding cattle). Both **Farm P** and **Farm G** calved in a single block. Both farms demonstrated a clear focus on fertility and stressed the importance to their model of maintaining a tight calving window.¹²⁰ As **Farmer G** explained:

“Calving interval is fairly simple for us: if they are not in calf in that 12 week period they do not stay here. There is no reason that I’m keeping an empty cow.”

The importance of a tight calving window related to the broader objective of reducing production (including labour) costs.¹²¹

The technologies deployed to support fertility on extensive farms provided a further contrast to those used on intensive farms. Crossbreeding – used by all of the extensive farms in the study – ensured ‘hybrid vigour’¹²² to boost fertility (DairyCo 2012b p.2:27; see 5.1.2, Table 5a). In addition, extensive farmers reported that, in the words of **Farmer G**: “A key driver in terms of the sires that are selected is fertility”. By comparison, intensive farms had historically focused on production [yield] traits when selecting sires (in the words of **Farmer I**: “in the past a lot of farmers were perhaps guilty of breeding for milk, milk, milk”) and had only recently considered a broader range of traits (such as fertility) when selecting sires. **Farmer P** summarised the differences in approach between the intensive and extensive system:

“Pregnancy rates drive our profit ... A Holstein breeder will be picking bulls to get a better [i.e. higher yielding] cow ... To maintain what we do we need about a fifty five to sixty percent conception rate¹²³ ... so [the bulls I select have] always got to be a plus on fertility, a plus on milk solids, fat and protein, and easy calving.”

The relationship between feeding and fertility also differed between extensive and intensive systems. For example, **Farmer G** explained that he supplemented grazed grass with concentrate feed, in order to improve cow condition and support fertility:

¹²⁰ **Farm P** was aiming for all cows to be pregnant within a window of 15 weeks and **Farm G** was aiming for a window of 12 weeks (with plans to reduce this to 10 weeks in the following year).

¹²¹ Which, in turn, related to the interaction between technologies and (labour) resources, see further below 8.2

¹²² “Heterosis/hybrid vigour is the tendency of a crossbred animal to have qualities superior to that of either parent but not more than the dominant breed.” (http://www.dairyco.org.uk/technical-information/breeding-genetics/crossbreeding/#.U6wbsKX_ZBU). In the words of **Farmer G**: “we are also very fixated on hybrid vigour, which is where the crossbreeding element comes in.”

¹²³ Conception rate is “the percentage of a herd becoming pregnant relative to the total number of services administered” (Cook 2009 p.262). Median conception rate for the UK national herd was 33% for the year ending 31 August 2014, based on a study of 500 Holstein/Friesian herds, <https://www.nmr.co.uk/uploads/files/files/HolsteinFriesian-500NMRherds-2014.pdf>

*"When they are turned out¹²⁴ they **are** fed other supplementary feeding ... they get fed a ration along with grass. But, unless we're having a poor season grass-growth wise, they'll always be getting a good element of their diet from grass... concentrate feeding ... I believe ... helps to put condition on our cows, which helps with the fertility."*

The farm's concerns about the potential impact upon fertility of underfeeding the cows, stood in contrast to the experience of some intensive farms, such as **Farm F**, which had been concerned instead about the impacts upon fertility of *overfeeding* the cows (see also **Farm P**, above). Put differently, **Farm G's** feeding approach was based around establishing the cows' minimum feed requirements (and meeting these, as far as possible, using grass) as opposed to identifying the maximum amount of feed that the cows could consume before returns to additional feed inputs began to diminish (and/or the cows became overweight; see above 7.1). Concentrate feed was therefore used only when grass was insufficient to meet these basic requirements, as **Farmer G** explained:

"[at the point when] grass growth matches the demand of the cows [around 15 April] ... I can pull out that [concentrate] ration, and the cows are then on ... 95% grass, and they'll still get an element of concentrate feed in the parlour, primarily to attract them into the parlour."

Farmer K's feeding approach was similar:

"We're getting about 6,800 litres per cow¹²⁵. And we try to get as much of that from grazed grass as we can, and if we can't use grazed grass, as much from other forage."

Monitoring and managing grass growth, and matching this to the cow's energy requirements, was therefore a key activity on these farms. **Farmer G** explained how this was achieved using a plate meter¹²⁶ for measuring grass growth, in conjunction with a grass management software tool called "Agrinet"¹²⁷:

"We plate meter the farm once a week. That gives us a read out of each field in terms of ... kilos of dry matter per hectare. We input that into ... Agrinet and that puts [the fields / paddocks] all in a bar graph, ranked from 'most grass' to 'lowest grass'. We then tell them how many cows we have, an estimate of how many kilos of dry matter per head per day that they are consuming, and what residual we require (which is the amount of grass left in the field)."

¹²⁴ "Turning out" refers to sending cows out to graze following a period of being housed.

¹²⁵ Mean yield for the extensive cluster of the Milkbench dataset was 6,706 litres per cow per annum

¹²⁶ A plate meter is a tool for measuring the amount of grass in a field:
<https://dairy.ahdb.org.uk/technical-information/grassland-management/using-a-plate-meter/>

¹²⁷ agrinet.ie

Farm P's approach was strikingly similar:

"We paddock graze. We grow a lot of perennial rye grass and white clover grass leys [which] are best managed in a rotational grazing system ... grass puts up a leaf every ... seven days. So ideally you want the cow to go back in the paddock twenty-one days after she was last in there ... We measure grass weekly on both farms with a plate meter. That information gets loaded into ... Agrinet ... And then we can look for any potential holes in the feeding... Where there's a hole ... you have to plug it with feed."

8.2 Interactions Between Component Categories

The configurations of technologies outlined above interacted in turn with other system components, notably physical and labour resources, as well as institutions (both 'cognitive' and 'normative' rulesets underpinning farmers' mindsets regarding their approach to farming and supporting progress towards existing system goals, which centred around the superiority of grass as a feed input and upon reducing labour inputs as a means of improving lifestyle).

Whereas on intensive farms the interaction between technologies and physical resources was characterised by farmers' efforts to limit the impact of climatic conditions upon the performance of high-yielding cattle (through the deployment of housing and feeding technologies¹²⁸), on extensive farms this interaction was largely characterised by farmers' efforts to maximise grass growth and utilisation within the limits defined by the climatic conditions.

Meanwhile, the interaction between technologies and labour resources was evidenced by extensive farms' preferred approaches to feeding (grazing and self serve feeding was favoured over the more labour intensive TMR or 'zero grazing' approaches used by intensive farms) and production cycle (seasonal block calving was preferred to all year calving, offering labour efficiencies through enabling staff to concentrate on one task at a time). Moreover, one extensive farmer reported a willingness to milk once (rather than two or three times) a day in order to reduce labour inputs. More broadly, the smaller cattle used on extensive farms were reportedly easier to manage, meaning a reduction in the requirement for labour resources in terms of person hours per cow.

These approaches to physical and labour resources appeared to be underpinned by farmers' mindsets, which incorporated beliefs (or cognitive rules), values (normative rules) and tacit knowledge. With regard to physical resources, there was a belief that grass is the best food for cows from both an economic, sustainability, physiological and ethical standpoint. With regard to labour resources, there was a view that labour should be minimised from both an economic

¹²⁸ Effectively, intensive farms had exchanged their exposure to variability in weather conditions for exposure to volatility in market prices for feed inputs.

and lifestyle standpoint. These farmers therefore farmed the ‘problem’ of dairy farming, and its solutions, in terms of the value of minimising feed and labour inputs.

Broadly, the extensive farms analysed relied as heavily as possible upon grazed grass, within the limits imposed by the available physical resources. In the words of **Farmer P**:

“We are grass based. In the South East [of England] you can't keep cows out all year round [as there isn't sufficient grass growth]... But the fundamental foundation of our businesses ... is to use as much ... grass as possible.”

Similarly, **Farmer G** would have preferred to keep his cows outdoors all year, albeit the climate did not allow this:

*“We **have** invested in a [cow] shed, which is not something we would have done if we were in the South West, say in Pembrokeshire, which is where I've just moved up from. But this area – obviously, we are now in the North East of Scotland – winters are going to be longer and harder.”*

Farm K provided evidence of how the interaction between selected technological configurations and available physical resources was influenced by the farmer's beliefs. First there was evidence of competition between the technologies used on **Farm K** and the available resources, specifically:

“Our farm doesn't lend itself particularly well to what you might call an ‘intensive grazing’ farm for Spring calving cows, in that our rainfall is about 22-24 inches (less than 600mm) in a year ... particularly in the summer, we're pretty dry ... and ... we have a lot of heavy land, so [the grass] doesn't grow really well in the early part of the spring.”

However, the farmer's decision to adopt an extensive system *in spite of* these resource limitations was supported by his mindset, or how he framed the problems and solutions of dairy farming. This incorporated both a normative (ethical / animal welfare) and an cognitive dimension (i.e. based on an understanding of what ‘works’ from both an economic and physiological perspective):

*“I've always been a passionate believer that grass is the cheapest food for cows and that cows should be grazing... cows as ruminants are designed to eat large quantities of average quality food [and] range over quite big distances ... they **should** be outside... I haven't got a problem with lots of cows together, but I have got a problem with them being inside 24/7.”*

Similar beliefs – albeit with an additional environmental dimension – were in evidence on **Farms G** and **P**. As **Farmer G** suggested:

"Grass is the cheapest possible feed you can put into cows [and] it's also the highest quality ... I strongly believe that ... On a personal level I feel that it's a sustainable way to farm. We're not pushing cows to the limit ... we're not pushing land to the limit. Not to say it's the high point of environmental friendly and welfare friendly [farming] ... it's not ... it's somewhere in between ... I feel that we have a duty to try and feed the population ... so there's going to be a cost to that ... and in terms of environmental [cost] the key then is to minimise that cost and maximise food production ... on a moral level I feel that we are achieving that very well compared to the Holstein system."

Meanwhile, **Farmer P**, maintained that:

"I'm interested in sustainable farming practices, so I'm interested in ... herbal leys, getting back to ... what we call 'conventional pastures' like my granddad used to grow, that didn't need the inputs."

For **Farms P** and **G**, the reduction of *labour* inputs, in particular, was also underpinned by values regarding the importance of achieving a 'work-life balance' (see 'normative rules', **Table 3a; 3.4**), combined with knowledge of how to achieve such labour reductions. **Farmer P** explained how these factors combined to form a mindset that underpinned the decision to adopt a low-input system:

"Before we invest a pound into this farm we just think 'Is this going to enhance our lifestyle?' ... We look at how much profit we make for how many man-hours it took to make that profit ... [and] come up with a figure per hour. So ... if you employ somebody else ... that figure should either go up or stay the same ... So everything we've done here has been basically to improve our lifestyle ... why do we create a better parlour? So we milk the cows faster, so we finish work earlier ... it might put more yield in the tank... [but] I don't really worry about that... I want to see farming ... conform more to other industries. So [when] you come and work for me you do your forty hour week ... There's no reason to make it hard work, we just do."

Farmer G expressed similar views on work-life balance:

"I ... feel [this is] the most profitable way to milk cows... I also feel it's the most labour-friendly, both from mine ... and from my staff's point of view. Certainly one of my key aims is to create a system that people enjoy coming to their work ... the traditional mindset in farming is that you work every hour that God sends and then you do some more, and that's not our focus at all... our mindset is very much that 'this is a job, you work to live, you do not live to work'."

The broader influence of this mindset upon the technologies used on these farms was clearly evident. The selection of both feeding and housing technologies supported low labour inputs – grazing plus 'easy feed' silage or in-parlour concentrate supplementation required less labour than the TMR approach favoured by intensive farms, while a shorter housing period meant lower labour inputs (for example, in the words of **Farmer G**: "They spread their own slurry, which is a huge cost saving"). Moreover, this mindset also had a bearing on **Farmer G's** approach to fertility (see above, **8.1**). The importance of maintaining a short calving interval was

emphasised by the fact that the farm had a policy of ‘drying off’¹²⁹ all cows at the same time (presumably) to reduce labour costs:

“We dry everything off on 1 December regardless of whether she calved on the 1 April or the 1 February ... [so] days in milk is what drives us...”

Finally, there was evidence of the influence of these beliefs upon milking, which is potentially one of the most labour intensive activities on a dairy farm. All of the extensive farms analysed had taken measures to reduce the labour demands incurred by milking. In the case of **Farm P**, this was manifested in a willingness to milking only once a day, at the expense of overall milk yields, a degree of flexibility that was permitted by the robust nature of crossbred cows:

“Part of our breeding policy is to have very adaptable cows, so you could always milk once a day ... we've actually done it here ... At this time of year when there's not many cows in milk because a lot of them are dry ... At some point we will all be on holiday between now and calving ... So if you're on your own you might just milk them once in the morning and not bother in the afternoon...”

For **Farms G** and **K**, the labour demands of milking were reduced through investments in rotary parlours, one of the few examples of large capital investments by the extensive farmers interviewed.¹³⁰ **Farmer G** explained that his investment in a 54-point rotary parlour with automatic teat sprayers and automatic cup removers meant that a single member of staff could milk 600 cows, while **Farmer K** suggested his rotary parlour was “the single most important technology” on the farm, adding that:

“I think the rotary parlour... is the thing that allowed us to expand, and actually milking is – whilst it's still a major job and a major issue in terms of staffing – if you've got a very efficient way of harvesting milk that reduces the time and cost and reduces the time that the cows spend stood about (so actually you can get the cows in and out and back to the grazing or back to the shed very, very quickly).”

Significantly, the size of these herds¹³¹ (which was a result of the high stocking rate enabled by the configurations of breed-feed-housing, described above, **8.1**) made the considerable capital

¹²⁹ <https://dairy.ahdb.org.uk/technical-information/animal-health-welfare/mastitis/working-arena-prevention-of-infection/dry-periods-resting-cows/>

¹³⁰ Notably, none of the extensive systems used robots, which would have served the same function (of reducing labour inputs), perhaps because of the potential incompatibility of robots with grazing, and with seasonal block calving (see **Chapter 7**).

¹³¹ With 600 cows (**Farm G**) and 660 (**Farm K**) cows, respectively, these were two of the largest herds in the study. The Milkbench mean herd size was 200.8 cows, with herds above 336.04 cows being in the 90th percentile.

investment in a rotary parlour economically justifiable.¹³² Moreover, the fact that rotary parlours require a herd size in excess of 350 in order to justify their high capital cost¹³³ represented an investment effect inhibiting future reductions in herd size.

As with the intensive farms analysed in **Chapter 7** (e.g. **Farm M**; above 7.2), there was evidence that farmers' beliefs supported (and were supported by) a clearly defined body of knowledge and skills amongst the farmer and farm staff, which had been developed through the operation of an extensive system. In the case of the intensive **Farm M** it had been evident that these skills and beliefs in turn supported (and were supported by) the continued use of certain technological configurations (i.e. as a result of bilateral complementarity and learning effects), which served to inhibit system change (from block to all year calving) in response to buyer demands.

However, in the case of the extensive **Farm K**, although evidence of such complementarity and learning effects was apparent, the farm *did* change system (from block to all year calving) in response to buyer demands (see below 8.3). This may be because:

- The complementarity and learning effects were weaker on **Farm K** than **Farm M** (e.g. the stocks of knowledge were more transferable); and/or
- The conditions of governance within **Farm K's** (aligned) value chain were different to those within **Farm M's** (non-aligned) value chain (e.g. sanctions were stronger, trust was greater etc; see further below, 8.3).

Farmer K explained that, after an all year calving model was "imposed" by his milk buyer (Waitrose, see 8.3), the technological changes that this necessitated had been easier to implement than the changes in mindsets that meeting the buyer's demands had required:

*"The thought [of changing calving pattern] was worse than [the reality]... and the mindset was the biggest problem ... because I was a block calver. And I'm **still** a block calver ... Putting positives through to the staff on the farm, you know, that we're now going to be calving every day of the year, we're going to be looking for bullers every day of the year, we're going to have a routine vet visit every fortnight... it was the mindset for me and my staff that was really difficult to change."*

¹³² "When both the labour requirement and the initial cost of ... [a conventional herringbone and rotary parlour] were evaluated, the conventional parlour was financially advisable for herds of up to 350 cows, whereas, the rotary parlour was financially prudent for herds of greater than 350 cows. The greatest disadvantage of the rotary parlour is the high capital cost compared to the conventional milking system" (O'Brien et al 2006, p.6)

¹³³ *ibid.*

The farmer added that changes in feeding, for example, were easier to implement than he had expected:

“My mindset said ‘we’re feeding cows in May, June, July with bought food that we shouldn’t have to use’, but ... In reality if you look at the litres they produced, we were slightly higher in total litres per cow and actually the extra food went into milk rather than perhaps what you might call ‘wasted’ ...”

8.3 The Influence of Buyer Power

This section considers the influence of buyer power upon the patterns of change outlined above (8.1 – 8.2), resulting from buyer demands relating to:

- Security of supply
- Product characteristics¹³⁴
- Production characteristics

Within each of these sections buyer demands the analysis considers how buyers seek to achieve compliance with these demands (i.e. conditions of value chain governance, including sanctions and trust).

As with the intensive farms analysed in the **Chapter 7**, buyer influence was greatest when buyer demands corresponded most closely with established systems goals, and where demands involved shallow rather than deep changes. Further, there was evidence of the importance of sanctions and trust to securing influence.

8.3.1 Security of Supply

The extensive farms analysed provided evidence of the successful efforts of milk buyers to influence farms with regard to the security of supply through the use of the following sanctions¹³⁵ (see also above, 5.2.6):

- **Base prices for milk**
- **The power to exclude**
- **A / B pricing**

¹³⁴ NB: The farm visits provided no evidence of farmers responding (or not) to food hygiene and safety standards above those required by statutory minima, hence the following discussion does not include a section dedicated to these.

¹³⁵ NB: There was no evidence of seasonality payments influencing the approaches of the extensive farms visited, hence the following discussion does not include a section dedicated to this.

8.3.1.1 Base Prices and the Power to Exclude

In 2002/3 Waitrose demanded that all of its farmers must produce a level year-round supply of milk. This demand was not accompanied by explicit bonuses/penalties for over/underproduction, and was separate from the supermarket's A/B pricing mechanism¹³⁶, but was instead underpinned by the threat of contract termination for non-compliance resulting in the loss of a historically superior base price for milk.

In the words of **Farmer K** – who had until that time been operating a Spring and an Autumn calving block, yielding a slightly uneven annual production profile – the supermarket “imposed” an all year calving model on the farm. The farmer outlined the depth of changes necessary to comply with this demand, which reportedly took four years to implement and affected ‘core’ farm activities. Chiefly, the move to all-year calving conflicted with the farmer’s beliefs about the ‘right’ way to farm, which centred on maximising the use of grazed grass (discussed above 8.2). Moreover, although the farmer suggested that altering this mindset presented the greatest obstacle to change, the process of switching to all year calving did reveal substantive challenges related to the deployment of both housing and feeding technologies on the farm.

With regard to housing, a reverse salient emerged following the move to all year calving, with the performance of the farm’s existing housing arrangements for calves ‘falling behind’ relative to the rest of the system. The farmer explained that the use of all-year calving with his existing housing arrangements had resulted in newly-born calves sharing “the same airspace and the same water trough” with calves that were several weeks old, resulting in the spread of pneumonia. To counter this the farmer constructed additional calf housing to separate calves of different ages.

A further reverse salient that emerged involved the performance of feeding and housing technologies. The feeding and housing approach that had worked successfully with a block calving model (namely, extensive grazing and minimal housing and feed supplementation) proved incompatible with an all year calving model, being unable to match the energy demands of the cows:

¹³⁶ Waitrose has, since it established a dedicated pool in 1998, operated effectively an A/B pricing system, whereby suppliers receive a premium price for milk delivered up to a certain limit, above which farmers receive the standard processor price. “They call [this] ‘modulated volumes’... [it’s] a contracted volume... [which] tends to run at an average of about 90% of what the [farmers] can produce, and they review that every couple of years, allied to the [consumer] demand that Waitrose have...” personal communication, Dairy Crest Direct spokesperson 14/1/15. See also 8.3.1.2

"In the summer months, we really struggled with ... 'metabolic' – or at least 'digestive' – disorders, where we were struggling to keep the cows full. We were giving them enough food in theory, but because we wanted them to graze a bit as well, they weren't actually [eating enough] ... we had a lot of trouble with displaced abomasums, which is twisted gut from not having the gut full, from the May / June / July calvers ... unless we kept them in [indoors] ... that ... caused quite a big vet & med issue ... it was a problem ... that I don't think I had seen until that point."

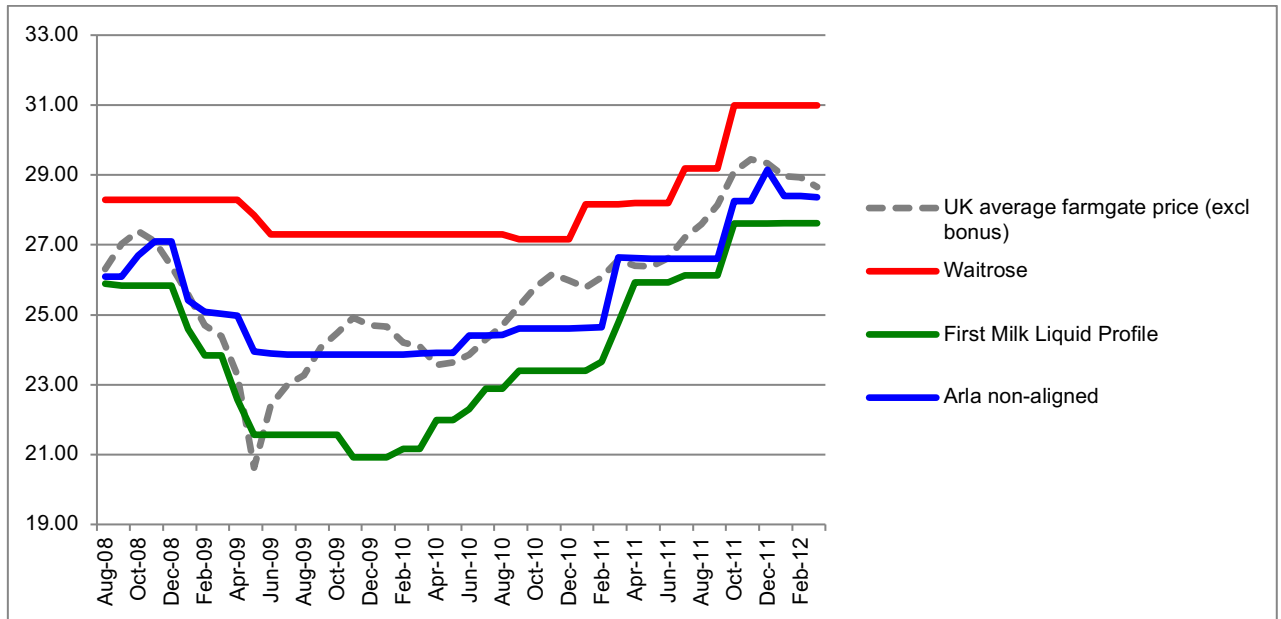
Finally, fertility (heat detection) issues emerged from switch to all year calving, with staff being required to detect bulling cows all year round, as opposed to in concentrated 'blocks'. This created the need for the introduction of new technologies ("scratchcards", see above, 8.1).

In spite of these challenges, the farmer complied with Waitrose's demands. The milk price paid under an aligned Waitrose contract was higher and more stable than prices available under non-aligned contracts, providing continuity, reliability and predictability. This strong positive sanction (and the associated negative sanction of the threat of losing the Waitrose contract) was perhaps instrumental in securing compliance. As **Farmer K** explained:

"Why are we still in a Waitrose contract? ... Because we have jumped through the hoops ... [and] we are in the position where, whatever hoop they chuck at us, we are gonna have to try and jump through it because ... why wouldn't you? It's bound to be worth it, at the moment ... Two or three years ago, actually, the Waitrose premium wasn't very huge... and there were people ... saying 'we could get as much money for our milk from somebody else without all the hoops'. I think the response was: 'well, go on then.' Nobody did!"

Over a 44-month period between August 2008 and March 2012 (see **Figure 8a**), the Waitrose contract paid an average of 28.35ppl, compared with 24.04ppl and 25.5ppl paid under the First Milk and Arla contracts, respectively. Moreover, over the same period, the Waitrose price changed 7 times (or every 6.29 months) compared with 17 times (or every 2.59 months) and 23 times (or every 1.91 months) under the First Milk and Arla contracts, respectively. As well as changing less frequently, the amount by which the price changed was also lower: the variance in the Waitrose price over the period was 1.55ppl, compared with 5.08ppl (First Milk) and 2.61ppl (Arla), demonstrating its greater stability.

Figure 8a: Milk Prices and Volatility: Aligned vs Non-aligned contracts



Source: Author (adapted from AHDB data¹³⁷)

A personal communication with a farmer representative highlighted the value of a long term, high, stable price to farmers:

*"If you look at any research on the original specialist pools, [of] M&S and Waitrose, ... the Capex [capital expenditure], of those farms is recorded to be four times more on a Waitrose or M&S farm than it would be on another retail contract."*¹³⁸

As well as demonstrating the effect of strong sanctions, the above example also provides some evidence of the conditions of trust within the Waitrose value chain. According to **Farmer K**:

"Waitrose said: 'we'd like you to be level' ... and I argued with them for five years, saying: 'we're nearly level' ... after five years of arguing I accepted defeat and we spent four years changing to all-year round calving and a completely level supply ... and at the end of the four years – and I have to say under some duress (there was quite a lot of heated exchange of messages, emails and letters) – we eventually became completely level ... So we got to the end of March and we were completely level for the year ... and on the second week of April I got a letter saying: 'Would you like to take part in a trial for seasonal production?!'"

¹³⁷ <https://dairy.ahdb.org.uk/resources-library/market-information/milk-prices-contracts/league-table-new-profile/>; <https://dairy.ahdb.org.uk/resources-library/market-information/milk-prices-contracts/uk-farmgate-milk-prices/>

¹³⁸ Personal communication, farmer representative 14/1/15

Although the farmer suggests that he acceded to Waitrose's demands under "duress", the length of time (nine years) between the buyer's initial demand and the farmer's ultimate compliance implies a high level of trust between the parties, and a bilateral or collaborative relationship between the two (5.2.6). Moreover, evidence of the degree of reliance that each party had on the other was demonstrated by the fact that the farmer didn't immediately accede to the buyer's demands, nor did the buyer immediately terminate the contract. Further, with regard to the nature and methods of communication within the value chain (see 5.2.6; Table 5f), communication between the farmer and buyer, while not always cordial, appeared to be frequent and bilateral (there were "*quite a lot of heated exchange of messages, emails and letters*"). Moreover, the buyer's offer to take part in a trial for seasonal production – while perhaps galling – does imply a degree of openness to the farmer's perspective on the part of the buyer.

It is also worth considering the degree of reliance that parties in the value chain have upon each other (see 5.2.6; Table 5f). It is significant to note that the Waitrose supplier pool comprises a relatively small number (c.50) of relatively large producers¹³⁹, many of which have enjoyed long-term relationships with the buyer (**Farmer K** had been a Waitrose supplier since 1999), conditions that are associated with "higher trust" chains (Kaplinsky and Morris 2001 p.74). Indeed, many of these farms had expanded having benefitted from a high, stable price, providing continuity, reliability and predictability, which enabled farmers to invest.

A personal communication with a spokesperson from Dairy Crest Direct (DCD)¹⁴⁰ – the producer group that represents farmers supplying Waitrose¹⁴¹ – provided further evidence of conditions of trust within the Waitrose value chain. Notably, he stressed that the value chain was characterised by the strength of personal relationships and "frequent and often informal" interactions between farmer and buyer (which are associated with "higher trust" chains; *ibid.*). Significantly, the Waitrose milk price (unlike the milk prices in other aligned value chains) is not calculated by reference to a formula (such as 'cost of production') but is set on a discretionary basis. Trust, therefore, appeared to result from trust in individual relationships, as distinct from trust in the process of price determination (as had been the case within the Tesco value chain; see 7.3.3.1). The DCD spokesperson explained:

¹³⁹ Indeed, **Farmer K** noted that: "The other issue about [us] being a significant size is that we can fill a tanker". Moreover, a personal communication with a Dairy Crest Direct (DCD) spokesperson (date: 14/1/15) revealed that: "because the contract has been very good there has been a lot of expansion within the pool [i.e. farmers increasing in size]".

¹⁴⁰ <https://www.dairycrestdirect.co.uk>

¹⁴¹ Personal communication, DCD spokesperson 14/1/15

“It’s amazing how informal the Waitrose deal, and the relationship with the farmers, actually is. They’ve never had to sign a side letter agreement between the Waitrose farmers and Waitrose ... so it’s amazing how the partnership has evolved and grown over the years and has embedded to become very firm ... there is an awful lot of trust that is there... It seems to have worked ... because they are dealing with such a small number of farmers ... because of the confidence it’s given those farmers they have all grown enormously, so ... they will be very big farmers across the pool...”

These conditions of trust appeared to extend beyond the relationships between supermarket and farmer. A personal communication with a processor¹⁴² revealed that certain relationships between processors and supermarkets exhibited greater continuity, reliability and predictability than others:

“[With] some supermarkets ... Waitrose and M&S in particular ... the relationships there are much more valuable than they are with the Tesco and the Sainsburys, Iceland ... For example, I cannot remember the last time Waitrose or M&S changed their processor: both of them have been dealt with by Dairy Crest for a long time. That’s not to say that other businesses didn’t get invited to tender ... but it would be very difficult to topple Dairy Crest because the relationship that Dairy Crest has with those two supermarkets is so strong. [Further] with some of the major supermarkets you tend to get dairy products handled in different buyer categories ... so depending on whether it’s a long life or shorter life product ... whereas in the smaller supermarkets – the Waitroses and M&S – the buyer tends to deal with dairy, full stop, so consequently it’s easier to negotiate a deal across products with a smaller supermarket than it is with the large supermarkets.”

Finally, in this case, the relationship between farmer and buyer appears to be based around shared beliefs or values, which implies a process of collective stabilisation of frames (Meyer and Schubert 2007). In the words of **Farmer K**: “our system probably lends itself – with the one exception of the level supply – to the ethos that Waitrose think they should have” (see further, 8.3.3).

This case provides a useful contrast to the example of **Farm M (7.4.1)**, in which the farmer switched buyer in response to an identical demand for all year calving, which, arguably, might have been more readily accommodated within the farm’s intensively housed system, requiring fewer changes to feeding approach, for example. In that case, sanctions were weak and the value chain was characterised by very low levels of trust. It appears that, where buyers’ demands do not correspond closely to farms’ progress towards existing goals, but instead require ‘deep’ changes, they must be accompanied by strong positive and negative sanctions, as well as conditions of trust in the value chain, in order to secure compliance.

¹⁴² Personal communication, milk processor 7/1/15

8.3.1.2 A/B pricing

Milk buyers use A/B pricing to control the volumes of milk that farmers supply to them. Because the goals of extensive farms are broadly centred on minimising inputs rather than maximising outputs, there is not necessarily an inherent conflict between the effect of A/B pricing and the positive feedback effects associated with extensive systems.

Although Waitrose does not describe its pricing scheme as an A/B pricing scheme, it does stipulate a fixed number of litres per day for which it will pay a premium price, with additional milk receiving the (lower) standard processor price (see above 8.3.1.1). The sanctioning effect of this arrangement is considerably less punitive than the A/B pricing schemes discussed in **Chapter 7**, such as the one described by **Farmer M** in which the “B” price was, at the time of the interview, 13.7ppl (see 7.3.1.3¹⁴³).

According to **Farmer K**, the number of litres that qualify for the premium price has increased consistently since he was been supplying Waitrose (1999), in line with the farm’s expansion (“The Waitrose [premium] litres have increased over the years as we have increased cow numbers”). However, this expansion was within system boundaries (Dosi 1988, p.226-7) and/or limits defined by the farmer’s beliefs:

“We have got to a level where I don’t think I can fit any more cows into our system. So if we want to continue to increase our Waitrose-allocated litres, we would need to increase yield per cow. I haven’t attempted to do that ... because... I think it’s back to my belief about cows grazing grass and not pushing them too hard ... Because the Waitrose premium is still relatively reasonable, and feed prices have come down ... that may have encouraged people to chuck more food at the cows ... It hasn’t particularly encouraged me because I’m fairly wedded to my system of ‘the cows graze when they can’.”

Therefore, although this may be viewed as a case of buyer demands influencing the farm to expand in herd size – as a result of the provision of a high, stable base milk price, allied to an increasing level of production for which that premium price would be paid – it should be noted that there was already a close correspondence between the buyer’s demand for more litres and the farmer’s existing goal of expanding the system – which had been motivated by his efforts to support an additional wage (“when I came back to the farm ... the accountant said ‘it’s gonna cost the farm £40 or £50,000 a year for you to be here: what are you going to bring to the farm?’ So I said: ‘well, we can bring some more cows’.”). Moreover, the effect of the buyer’s demands

¹⁴³ By means of comparison, the standard Muller price that Waitrose farmers would have received for non-premium litres on that day was 24.70ppl; <https://dairy.ahdb.org.uk/resources-library/market-information/milk-prices-contracts/league-table-new-profile/>; <https://dairy.ahdb.org.uk/resources-library/market-information/milk-prices-contracts/uk-farmgate-milk-prices/> (NB: Muller took over Dairy Crest’s liquid milk business in January 2016: <https://www.fginsight.com/news/news/name-change-for-muller-wiseman-as-dairy-crest-deal-completed-8918>)

was to influence the scale of the system rather than to alter the production approach (i.e. it was not 'deep').

8.3.2 Product characteristics

8.3.2.1 Sanctions: Bonuses / Penalties for Constituents

Farmer G explained how his current contract – with Graham's the Family Dairy – had influenced breeding technologies on the farm. He explained that the genetics of his Jersey-Friesian crossbred cows are "weighted slightly towards the Friesian, because ... we are on a liquid-based contract":

"We run a New Zealand-style¹⁴⁴ system, but we're not in New Zealand ... [in] New Zealand they are paid on kilogrammes of milk solids... we are paid pence per litre, so at the end of the day we produce volume, which is what our market wants."

He explained that – although Graham's currently rewarded the production of butterfat – his preferred system would be better suited to a cheese contract, which paid a bonus for the production of both butterfat and protein:

"We also produce a lot of protein because of the way we manage [the cows]. So the holy grail for this type of system is to be on a cheese contract, because it's a high protein product and it's also got a long shelf life ... And there are changes that can be made [to the system to increase protein levels further]... we can certainly tailor the feed in a little bit more towards the protein...[we can] change the breeding strategy and take it slightly away from the Friesian and more towards the Jersey..."

In the absence of a bonus for protein, however, the technological approach to feeding and breeding on this farm was being influenced by buyer demands for volume and butterfat.

8.3.3 Production Characteristics

Waitrose made a number of demands regarding production characteristics, which **Farm K** had complied with ("When they have audited we've made sure that we passed the audit. They wanted us to spend some of the premium that they give us on improving cattle welfare. We've done that"). For example, the farm was required to stop feeding soya hulls, and the buyer also insisted that male calves should enter Waitrose's beef supply chain. These demands were easily accommodated within the farm's existing system (i.e. they didn't require 'deep' changes): soya hulls were replaced with rolled oats, while the farmer's uncle – a beef farmer since 2000 – was a Waitrose beef supplier.

¹⁴⁴ i.e. grazing-based

Broadly, the goals towards which **Farm K** was progressing appeared to correspond closely with the goals towards which the buyer was aiming to direct it:

“Waitrose ... are very keen on the environment, and ... [in] what we are doing to reduce our ... damage to the environment ... They set up a scheme that we should all take part in... well it was actually stuff that we were already doing. So we had originally a Countryside Stewardship agreement and then when Entry Level Stewardship came in we were very happy to take on that, and indeed [now] we’ve got a Higher Level Stewardship scheme going on the farm ... so as a business, that’s our ethos... and ... that fitted very well with Waitrose... Currently ... they’re promoting 100 days grazing... well ... If they’d said ‘a hundred and eighty days’ ... I’d be happy to meet that.”

The exceptions to this are buyer demands for a level year round supply of milk, requiring all year calving, (see above 8.3.1) and individual milk recording, which **Farm K** introduced at Waitrose’s request. Again, the farm’s willingness to comply with this demand appeared to result from farmer’s mindset (i.e. comprising the farmer’s knowledge beliefs and values):

“They want us to record the cell count per cow. Actually the most recent thing – and the cell count recording ties up with this – is anti-microbial resistance and a wish to use less antibiotics ... knowing the infection status of your cows is actually really important... and it does mean that we have used dramatically less dry cow therapy¹⁴⁵ than when we started cell count recording. We were blanket treating everything, and now we do 30-35% with antibiotics at drying off... It’s the right thing to do.”

Although Waitrose did not benchmark farmers in its producer group against each other (cf. Tesco and benchmarking; 7.3.3), there was evidence that involvement in the producer group had resulted in expectation and co-ordination effects, with the potential to influence production approaches. **Farmer K** explained:

“We meet as a [producer] group a couple of times a year. There are regional subgroups [and] if there’s some sort of training or something going on that [Waitrose] want transferred out to the producers there will be little groups that meet possibly another couple of times a year ... Representatives of the producers ... meet with Waitrose on a regular basis ... and finally they have a ‘study tour’ ... [which is] an opportunity to interact with Waitrose and find out what the buyers are thinking...”

For example, the farmer recalled a “study tour” to Canada in 2007:

“We went to various really high producing herds ... I can vividly remember looking at these big Canadian Holstein cow ... and one of the Waitrose people said ‘What do you think of these cows?’ and I said ‘Well, as far as I’m concerned, they are horrible!’... and the reply was ‘I completely agree. That isn’t what we want our farmers to be using’... It just showed me that we were heading in the same direction as Waitrose.”

¹⁴⁵ Dry cow therapy is “the treatment of cows at the end of lactation with a long acting antibiotic preparation with or without a teat sealant. This is to treat for any intra-mammary infections (IMI) contracted during lactation and provides protection against new infections during the dry period; https://en.wikivet.net/Dry_Cow_Therapy

The dairy cow – viewed as a technological artefact – is subject to a degree of “interpretive flexibility” (Pinch and Bijker 1987, p.36) with regard to the meanings that various actors may attribute to it (as evidenced by the wide range of different breed types, with different functional traits; 5.1.2). This interaction between the farmer and the buyer reveals bilateral complementarities between the farmer’s meanings those of the milk buyer, implying a process of collective stabilisation and closure around a technological frame.

Although he had made the decision to forgo his Tesco Direct contract in favour of Arla co-operative membership (see below, 8.4.2), **Farmer P** was still required to meet certain production standards determined by Tesco, and to submit accounts data to the supermarket. He explained:

“We get the Arla price [and] We get a tiny bit extra for Tesco taking the milk and in return we have to do a little bit extra work, which is not more really than we do already ... And we have to locomotion score¹⁴⁶, we have to submit our drug usage to Tesco.”

Although complying with buyer demands, he suggested that this hadn’t required him to make any (‘deep’) changes to his current system, however:

“You have to keep those records ... All those records are here, all we are doing is pushing the button and sending them.”

8.4 When Buyer Power Fails to Influence Technological Change

8.4.1 Security of Supply

8.4.1.1 A/B pricing

Theoretically, buyer-imposed limits on the number of litres per day on which farmers receive a premium milk price has the potential to influence the farmer to limit their production and/or to smooth the profile of milk delivered. In the case of **Farm K**, this was not the case:

“There is a set number of litres per day that Waitrose will pay a premium for... and obviously on a seasonal pattern sometimes you are producing twice as much as that [number] and sometimes you’re not producing as much ... and so whilst that potentially isn’t a massive issue, there is a premium there that you are not using ... I set it up [the two block calving system] thinking that as long as we always produce up to somewhere near the premium, and then for some parts of the year we’re going to be producing massively over it.”

¹⁴⁶ Locomotion scoring is a system for “measuring levels of ease of movement and locomotion in dairy cattle” (<https://dairy.ahdb.org.uk/technical-information/animal-health-welfare/locomotion/>), as distinct from mobility scoring, which is a system to “assess lameness prevalence – the number of animals lame at any one time – in a given herd” <https://dairy.ahdb.org.uk/technical-information/animal-health-welfare/locomotion/husbandry-prevention/mobility-scoring/>

Farmer G's buyer – Graham's – had also imposed an A/B pricing scheme. Within the scheme, the 'A' price was calculated as a standard litre price, with a bonus for butterfat, while the 'B' price was based on the spot market price, which the farmer reported was 10ppl ("I don't think there's a farmer in the world that can make money out of that"). The number of litres that would receive the 'A' price each month was calculated as 90% of the farm's total production for the previous year, divided by 12. The farmer explained that this had a serious impact on the profitability of his Spring-calved system because during the months of peak production "we've got a huge chunk of our milk being sold at 'B' litres". However, in spite of the strong sanctioning effect of this pricing scheme, it had failed to influence the farmer's production approach:

"We contemplated making major changes to the system in terms of putting two calving blocks in, but when it came down to it we were fractionally better off to stay purely Spring calving... it would have needed to be significantly better to have gone split calving, because it does make major changes to what you're doing and the cost of production would change ... you'd have cows ... winter milk ... fully in the shed, fully fed on bought-in feed, and needing bedding ... you'd have more slurry to spread ... [And] we have a two month down period when we are not producing milk, which provides rest and recuperation for staff... so you'd lose all of that and gain all that cost."

Put differently, given the depth of changes required to switch calving pattern – which would have affected both technologies and labour resources, and conflicted with the farmer's beliefs about the 'right' way to farm – even stronger sanctions would have been necessary in order to make the move worthwhile.

Chapter 9: Technological Change in Intermediate Farms

The distinctions between intensive and extensive farms should be clear, from the preceding chapters (**Chapter 7** and **8**), with these farms lying at either end of a continuum of system types. However, distinguishing intermediate farms from both extensive and intensive farms presents a greater challenge because, as outlined already (**5.1.2**), farm systems are typically differentiated from each other by reference to scale variables rather than categorical variables, with the result that boundaries between clusters may be indistinct or arbitrary.

Related to this (as discussed in **Chapter 6**), the use of principal component analysis and cluster analysis to develop ‘clusters’ of farms corresponding to intensive, intermediate and extensive farm systems provides an approximate rather than a precise or definitive method of deriving such categories, because it relies upon the use of scale variables to define clusters, rather than doing so by reference to the use or non-use of certain technologies or combinations of technologies. Indeed, the definition of the clusters is dependent upon the composition of the sample (farms are therefore only categorised as being ‘intermediate’ relative to the rest of the farms in the sample, and therefore rely for their identification upon the presence of more and less intensive systems. Moreover, the *rate* of intensification relative to other farms in the sample also becomes a relevant consideration, as a farm that was – relative to the sample – ‘intensive’ or ‘extensive’, say, ten years ago may now be categorised as ‘intermediate’ if the rest of the sample has intensified or extensified more or less rapidly or to a greater or lesser extent).

Allocating farms to the intermediate cluster was, therefore, challenging. For example, **Farm H**¹⁴⁷ was allocated to the intermediate cluster by the principal component analysis, but the qualitative interview data suggested that it could conceivably have been categorised as an extensive farm. Further, **Farm E**¹⁴⁸ – similarly on the ‘border’ between intermediate and extensive systems – is included in this chapter rather than in the extensive chapter as it appeared to be in the process of intensifying towards a position that would have placed it more firmly within the intermediate category. Finally, because they had ‘a foot in each camp’ intermediate farms appeared to have a wider range of possible options for future development in response to milk price changes (i.e. greater flexibility to change *between* clusters than either extensive or intensive farms).

¹⁴⁷ Non-aligned Farm, interview date: 7/7/16 see timeline **Appendix 9A**

¹⁴⁸ Aligned Farm, interview date: 6/7/16; see timeline **Appendix 9B**

This chapter follows the same structure as the previous two chapters, namely it divides the analysis into a description of farm socio-technical systems in terms of inputs and outputs and the positive feedbacks associated with the interactions between technologies (9.1) and between technologies and other components (9.2) which serve to highlight farms' progress towards system goals; followed by an analysis of the influence of buyer demands, by reference to conditions of value chain governance, upon this progress (9.3).

9.1 Interactions Between Technologies

Similar to the intensive and extensive farms analysed in **Chapters 7** and **8**, respectively, intermediate farms provided evidence of interactions between technological components, notably those associated with feeding, housing and breeding. However, within such interactions, components often appeared to be in competition with each other rather than complementing each other's performance.

Moreover, and perhaps unsurprisingly given that intermediate farms occupy a 'middle ground' on the continuum between intensive and extensive systems, these technological configurations appeared to support progress towards a less clearly / narrowly defined set of system goals when compared with intensive and extensive farms (in which technological configurations supported progress towards either the goal of maximising output per cow / milking robot in the case of the former, and towards the goal of minimising feed and labour inputs in the case of the latter).

For example, while extensive (intensive) systems were focused on exploring the limits of minimising (maximising) feed and housing inputs, and therefore selected breeds of cattle that complemented those approaches (7.1; 8.1), the use of specific cattle breeds was less critical to the performance of intermediate systems, and the particular traits of these cattle (i.e. hardiness or yield potential) were typically not being exploited or 'pushed' to the same degree through the deployment of feeding and housing strategies.

Farmer J¹⁴⁹, for example, farmed a herd of 120 Autumn-calved pedigree Holstein cows, which was, he suggested, "the highest £PLI herd in the United Kingdom".¹⁵⁰ Although these cows

¹⁴⁹ Non-aligned farm, interview date: 31/05/2016; see timeline **Appendix 9C**

¹⁵⁰ "Profitable Lifetime Index" (£PLI) "is a within breed genetic index developed specifically for UK dairy farmers. The £PLI value represents the additional profit a high £PLI bull is expected to return from each of its milking daughters over her lifetime compared to an average bull of £0 PLI" (<https://dairy.ahdb.org.uk/technical-information/breeding-genetics/£pli/>)

were each yielding 10,100 – 10,200 litres¹⁵¹ per annum, the farmer explained that they could have produced even greater volumes of milk (see 9.3.1.1) had he chosen to feed them more intensively with concentrate feeds and to rely less upon grazed grass. Although it was towards the intensive end of the intermediate cluster, the farm was nevertheless typical of the intermediate approach, incorporating elements from both intensive systems (i.e. pedigree Holsteins) and extensive systems (paddock grazing and the use of a plate meter to measure grass growth; see 8.1). The farmer explained:

“It isn’t [a pure] grazing [system], but it’s slightly further towards the grazing system than the high output system, because they are certainly nowhere near fully housed ... the main priority is to get as much forage in the diet as possible ... to some extent to the detriment of yield...”

The farmer had taken the decision to increase the forage component in the cows’ diet with the aim of reducing feed input costs (see further 9.3). His approach to feeding had also been influenced by the use of milking robots, introduced in 2009/10 (see below, 9.2). Similar to intensive **Farm O** (see 7.1), the introduction of robots had required the farmer to feed concentrates *inside* the robot, rather than in the cows’ usual feed ration, in order to attract cows to walk to the robot for milking. However, by contrast to the intensive farms that were using robots (see **Farmers I and O, Chapter 7**), the farmer had not moved to a permanently housed system to support maximum ‘cow flow’ to the robots.¹⁵² Moreover, the farmer was also operating a seasonal (Autumn) calving model rather than the year round model favoured by the intensive farms that had introduced milking robots.

Just as the farmer’s use of grazing limited his ability to extract maximum yield from his pedigree Holsteins and to maximise cow flow to his robots, his use of robots also prevented him from maximising the use of grazed grass. As **Farmer J** explained:

“The cows are milked with robots ... so grazing is difficult, but they are grazed from April through to October, depending on the weather ... a strict grazing man ... wouldn’t see it the same... the cows go out and they are allocated a daily area of grass... [which] is ... probably no more than 25% of their forage intake for the day ... and the rest of their forage intake is fed in the sheds... Using the robots actually prevents me from using a fully grazed system because if I didn’t have to have the cows with 24 hour access to the robots, I could graze the other side of the road...”

¹⁵¹ Compared with the mean for the whole Milkbench sample (7,738.71 litres) and for the intermediate cluster of the sample (7,458.92 litres)

¹⁵² The cattle were housed for 33 weeks of the year. By comparison the mean housing period for intensive farms in the Milkbench dataset was 44.59 weeks.

Put differently, these breeding, feeding, housing and milking technologies might be regarded as *competing with*, rather than complementing each other, and the system was characterised by the trade-offs and tensions made between these various technological components, rather than by complementarity effects between them. Nevertheless, it was clear that the system permitted a degree of flexibility, perhaps because it was characterised by competition rather than complementarities between components. As **Farmer J** explained:

"At the moment concentrates are dear and forage is cheap, so therefore we push towards forage. But if wheat prices drop to £60 a tonne and soya to £100 a tonne ... I'd swing back the other way ..."

The flexibility inherent in the technological configurations used on **Farm J** was therefore mirrored by the farmer's mindset (see further 9.2, below).

Like **Farmer J**, **Farmer C**¹⁵³ also outlined the trade-offs and tensions involved in combining elements of both intensive and extensive systems. He described his farm – which comprised a herd of 500 Holstein cows, across two sites, calved all year round and yielding 9,000 litres – as being "in the middle of two systems". The cows were housed for between 26 and 30 weeks of the year (compared with a mean of 31.96 weeks for the whole Milkbench sample, and 26.86 for the intermediate cluster). The farmer explained:

*"Our main feed is grass silage, a little bit of wholecrop¹⁵⁴ forage, and we have blends. Quite often we'll feed brewers grains, and we'll feed **a semi-TMR ration through the winter**, topped up with cake [concentrate] in the parlour twice a day ... We want high production [but] we still want some cheap grazed grass, so **we've got sort of a hybrid model** ... We're feeding silage and cake ... we're letting them out to grass and still feeding in the parlour. [But] **you can't get the best out your grazing when you're feeding** because they've been out dumping all that muck on the field, and they're not hungry enough to bare the field off level. So you get very selective grazing." [emphasis added]*

In other words, the system appeared to be characterised by competition (as opposed to complementarity effects) between the different feeding technologies deployed (grazing vs intensive feeding). This was mirrored to some extent by the farmer's own mindset (and his ambivalence about his future plans for the farm; see 9.2 and 9.3, below).

Farmer D¹⁵⁵, who also farmed Holsteins – a herd of 480 Autumn-calved, TMR-fed cows yielding 10,000 litres each – described his system as "middle-of-the-road". The farmer explained that the

¹⁵³ Aligned farm, interview date: 19/7/16; see timeline **Appendix 9D**

¹⁵⁴ <http://www.thedairysite.com/articles/3670/wholecrop-a-potential-alternative-forage/>

¹⁵⁵ Aligned farm, interview date: 28/7/16

system had been more intensive when he returned to the family farm in 1994, at which time the cows were milked three times per day and fed using a TMR approach. He recalled his attempt at the time to switch to an extensive system:

"We then went to try an extensive grazing system, thinking we were going to reduce lots of costs, so we took out the third milking, put in the paddock grazing system, and tried to graze cows from the middle of February to the middle of December. And it didn't work. It's too extreme for this farm and for the cows we had. So we came back to a middle-of-the-road system... [And] I think we feed better now than we ever have done ... the whole emphasis of the business is to get the diet and everything right for the cows so it should produce naturally, rather than trying to fill her with feed and force her..."

On the date of the interview, **Farm D** housed its cows for approximately 26 weeks and grazed for the remaining 26 weeks of the year (mean housing period for the intermediate cluster was 26.86 weeks).

Similar to **Farmer D**, **Farmer B**¹⁵⁶ housed his cows for approximately 26 weeks of the year and operated a single Autumn calving block. He suggested that "We're on a cross between the two systems". The farmer described his system as a "housed-system-stroke-grazing-system", which is perhaps best understood as operating intensively during the winter months, and extensively during the summer.

Although **Farms B** and **D** were not housing their cows for significantly longer than the typical extensive farm¹⁵⁷, their operation of a single Autumn calving block – which accompanied the more intensive feeding of the cows during the Winter (housed) period, when the cows were early in the lactation cycle and therefore experiencing peak energy demand – distinguished them from extensive systems such as **Farm G (8.1)**, which operated a Spring-calved block and therefore kept the cows outdoors to graze at the peak of lactation (energy demand) and accordingly fed less intensively during the housed period. They were also distinguished from the extensive **Farm P** – which was Autumn calving – by their longer housing period and the greater attention they appeared to place upon matching feed inputs to the cows' stage of lactation (whereas **Farmer P** adopted an 'easy feed' approach; 8.1).

Farmer B explained the feeding-housing-fertility-calving pattern interactions associated with his approach:

¹⁵⁶ Non-aligned farm, interview date: 20/7/16; see timeline **Appendix 9E**

¹⁵⁷ Mean housing period for extensive farms in the Milkbench sample was 24.56 weeks

"[We're] trying to push the cows as much as we can to get the peak yields as high as we can during the Winter, at an efficient rate ... [and] once we get to the end of January / February we start looking to cheapen the diet up because the cows are hopefully getting back in calf. The majority are all back in calf then. We try and extract more efficiency from the cows and then [the lower feed input] is not having detrimental effect too much on the milk yield at that point because it's passed the peak ... During the Winter, we're very focused on the health and the fertility ... Once back in calf, we can just ... try and extract a little bit more out of them and push them a little bit harder, knowing they've already got in calf, so they're not gonna have a reduced conception rate..."

This feeding approach stood in contrast to the approach taken by intensive **Farmer F**, for example, who fed a "potent" feed ration (7.1) throughout the cows' lactation and therefore had to take care to ensure that the cows did not become overweight and "hard to calve back in". Instead, **Farmer B** initially fed to yield¹⁵⁸ before appearing to switch to a 'flat rate' feeding approach,¹⁵⁹ before increasing the ration once more, once the cows were in calf.

Competition between the different feeding technologies used on **Farm B** was less pronounced than in some of the other intermediate farms outlined above. Instead, complementarities between feeding and housing appeared to be mediated by the selected calving pattern, with intensive feeding and housing complementing each other during the early stages of lactation and more extensive feeding and housing complementing each other later on. Once the cows were in calf, the intensity of feeding was increased without compromising fertility. The *timing* of feeding changes was therefore determined by fertility considerations.

Although **Farmer C** had complained of "selective grazing" (i.e. competition between his chosen feeding technologies) his feeding approach was similarly mediated by calving pattern and fertility considerations:

"It's a stepped [feeding] system really¹⁶⁰. We build them up from when they calve. We have a good transition period, and aim to get them peaking ... and we'll hold them at that and then ... as they start dropping off [in yields], we will step 'em down [i.e. reducing feed]. But we hold them at a fairly high concentrate level because we want to hold that lactation. Then when we know they're in calf... we'll challenge¹⁶¹ them in later lactation. So early Spring ... we'll gain

¹⁵⁸ **Feeding to yield** involves "Allocating concentrates on a daily or weekly basis according to yield ... Feeding to yield tends to result in lactation curves with a higher peak yield but more rapid decline as cows respond positively to the challenge of more generous early lactation feeding and negatively to the progressive restriction of allocations in mid to late lactation" (DairyCo 2012b, 6:13)

¹⁵⁹ **Flat rate feeding** is "Completely opposite to feeding to yield, flat rate feeding involves providing all cows with the same quantity of concentrates each day throughout the lactation" (DairyCo 2012b, 6:14)

¹⁶⁰ **"Step concentrate feeding** provides a convenient half-way house between feeding to yield and flat rate feeding, more closely meeting cows' nutritional needs at each stage in the lactation, while maintaining as much simplicity as possible." (DairyCo 2012b, 6:14).

¹⁶¹ **Challenge feeding** is "a system of feeding dairy cows which provides more feed than is justified by the level of the individual cow's milk production. In the early part of the lactation the cow is challenged to

some feed off cows that are in calf, and that are not going to lose a lot of condition, we'll ask a lot [of them] from grass ... and likewise if we've got very good silage ... we'll challenge those cows. They'll be in a lower yielding group which have a lower blend ration..."(emphasis added)

The intermediate farms also provided evidence of fertility-calving pattern interactions, similar to those observed on extensive farms (8.1), in which reverse salients, resulting from the application of a block calving model (with its requirement for getting all cows pregnant within a narrow 'window' when compared against all year calving models), had led to the adoption of heat detection technologies aimed at reducing the calving interval.

Notably, whereas extensive farms had favoured 'low-tech' heat detection solutions such as 'crayons' or 'scratchcards' (**Farms G and K, 8.1**), and intensive farms had favoured heat detection collars (**Farms O and M, 7.1**), many intermediate farms chose to outsource the function to third party providers who would detect heat manually. Upon switching to Autumn calving in 2010, having previously operated an all-year calving model, **Farmer B** had contracted out heat detection to a consultant, which had reduced the calving interval from 400 to approximately 369 days.

Farmer E had also outsourced heat detection services to Genus – using the company's "RMS"¹⁶² service – having previously used heat detection collars. Since employing the services of Genus, calving interval had reduced from 405 days to 391 for the herds' Holsteins and from 390 to 363 for the herds' Shorthorns. **Farm N**¹⁶³ was also using RMS, while **Farm C** used both RMS and collars:

"A big management part of this farm is we use RMS services. We used to just run natural service bulls through the herd. About five years ago, we changed and we started recording all the data ... we PD¹⁶⁴ every week so we've got exact dates on when to go 'dry', and when calving. It's revolutionized the management. Before that it was a lot of guesswork ... [and] some cows were in far too long in the dry period, gaining the wrong condition ... We realise now we've gotta have the cow in the perfect, best condition we can get her for the coming lactation..."

produce more milk and in many instances does so. If the cow does not respond the level of feeding is reduced. Called also lead feeding because the cow is led to produce more heavily." Saunders Comprehensive Veterinary Dictionary, <https://medical-dictionary.thefreedictionary.com/challenge+feeding>

¹⁶² <http://www.genusbreeding.co.uk/?p=1615>

¹⁶³ Non-aligned farm, interview date: 20/7/16

¹⁶⁴ Pregnancy diagnosis

Farm D and **Farm L**¹⁶⁵ both used 'Heat Time' collars. **Farmer H**, by contrast, used neither collars nor RMS. The farmer explained:

"The calving index is about 420 days ... either they get in calf during that 12-month period or they tend to have a very long extended lactation because they've run around and they'll be 24 months later when they calve. So it's all about getting more and more in calf in the 12-month calving and less that run round."

On the date of the interview, the herd was entirely composed of Holsteins. The farmer, however, was considering crossbreeding, due to concerns over inbreeding (and its impact on fertility). The use of increasingly narrow bloodlines (a co-ordination effect at the sector level, resulting in a convergence upon a Holstein-based model of production) was resulting in a reverse salient (due to the reduction in genetic diversity of cattle at the sector level, associated with this convergence) , requiring the use of further technologies, such as inbreeding checks:

"When you look at something with Oman in... and all of a sudden you work out that 90% of the bulls have got Oman in them¹⁶⁶... and nearly half of them come out of one cow ... you can use the mating programmes and you can use herd indexes and everything, but then you also need to use an inbreeding code, and checkers, because by focusing just solely on one trait, the industry as a whole has ended up with narrower and narrower-bred bloodlines... it's got to the stage now where you have to check the bloodline as well, as well as just checking whether it's got the right type and fats and proteins..."

Although most of the intermediate farms interviewed farmed Holstein cows, some had incorporated other breeds into their systems. For example, **Farmer B** described his cows as being "not 'Holstein' Holsteins":

*"Ours have a little bit more flesh on them. [They are] not as tall and not as heavy ... when they're grazing if you've got too much weight on feet you start making indentations into the floor [sic] and damaging the swards by 'poaching'¹⁶⁷... [but] If you get too light they [also] produce less milk ... We're about 625 kilo cows, rather than extremes [which] might be 700, 750. But on the complete Spring calving ones they might be down at 500 kilo ... So **we're somewhere in the middle** ..." [emphasis added]*

These 'smaller' Holsteins clearly complemented the farm's grazing-based approach in the summer months, without being so small as to compromise the farm's more intensive housed approach in the Winter. Moreover, **Farmer B** had also, approximately ten years before the date of the interview, introduced some Holstein-Jersey crossbreeds to the herd. Significantly, these

¹⁶⁵ Non-aligned farm, interview date: 19/7/16

¹⁶⁶ <http://www.fwi.co.uk/livestock/oman-and-sons-still-dominate-holstein-proofs.htm>

¹⁶⁷ 'Poaching' refers to the compaction of soil due to trampling by livestock:
<http://www.gov.uk/guidance/rules-for-farmers-and-land-managers-to-prevent-water-pollution>

breeding changes had not been influenced by the desire to produce a cow better suited to grazing (which was the objective of extensive farms that had introduced crossbreeding; see **Farmer P; 8.1**). Instead crossbreeding was introduced because “we had too many maiden heifers having caesareans on their first calf” and “the Jersey calf will come out of the cow a lot easier”.

Farm E, like **Farm B**, was not farming exclusively Holstein cows, but farmed a mixed herd of 90 Holsteins and 90 Dairy Shorthorns (a traditional breed that had been on the farm for several generations, pre-dating the Holsteins), yielding 8,200 litres (averaged across the herd), and operating an all-year calving pattern. The cows were housed for five months (21.73 weeks) of the year, placing them towards the extensive end of the intermediate cluster. However, the farm had operated more intensively in the past and was milking three times a day when the farmer “came home” to the farm in 2006 at which time there were only 30 shorthorns in the herd and yields were 10,000 litres-plus.

This farm, with its 50:50 split between Holsteins and Shorthorns, exemplified the potentially conflicting nature of the technologies associated with intermediate systems. On the one hand, the farmer used in-parlour feeding and a ‘feed to yield’ strategy, complementing the farm’s all year calving pattern:

“We feed in the parlour. We have always fed in the parlour. It’s an intensive way of looking at it. It’s a very good way of focusing in on an individual cow and giving her food that suits her own personal needs, rather than blanket feeding the lot.... because we calve all year round... so if you looked at the herd at any point in time you’ve got cows at different stages of production. So you have the ones that are freshly calved that have very high needs ... to the ones that aren’t giving much milk that have low needs ...”

However, on the other hand, **Farm E** was also using paddock or ‘rotational’ grazing, with a view to maximising the use of grazed grass.¹⁶⁸

Elsewhere, **Farm E** also provided evidence of the complementarities that exist between milking technologies, housing technologies herd size, and of the sequence in which technologies were required to change as the farm expanded (as well as of the interactions with, and dependencies of these upon, financial resources, see **9.2**):

“[Having purchased a new milking parlour] what we need to do now is extend our cow numbers ... so we’re 180 cows [and] in the ideal world we would just go up to 200, because the 20 extra

¹⁶⁸ **Rotational grazing** involves “moving **grazing** livestock between pastures (often called paddocks) as needed or on a regular basis”; <https://www.premier1supplies.com/sheep-guide/2012/07/a-look-at-the-advantages-of-rotational-grazing/>

cows would just help pay for the cost... But we can't do it at the minute because we are constrained by housing... so until we get more housing... it's a bit like a chicken and egg thing..."

Finally, there was evidence of an interaction between housing, grazing and waste management technologies on many intermediate farms. With these farms housing their cows for half of the year, this created a need to manage considerable volumes of slurry (as distinct from some extensive farms, such as **Farm G**, on which the cows "spread their own slurry"). Moreover, because these farms also wanted to make efficient use of grass during the Summer months many of them (**Farms B, H, E, D**) chose to use umbilical systems to inject slurry into the ground rather than spraying it onto the surface. **Farm B** explained the reasoning behind this:

"During the Summer ... we inject [slurry] into the ground ... Because it's going directly into the ground you've got less ammonia into the atmosphere. And then also, with our system it works really well, because we can graze 12 days after you've done the injecting ... the old fashioned way, the spread plate way¹⁶⁹, you'd be talking a month, six weeks before you can graze in it."

9.2 Interactions Between Component Categories

The technological configurations used by intermediate farms interacted with other categories of system components: resources (chiefly labour and physical), and the knowledge and skills embedded in actors and the labour force, as well as their beliefs (institutions) that supported and were supported by such knowledge and skills. There was some evidence that these interactions supported a degree of flexibility and/or responsiveness in intermediate systems, in the face of changes in market prices, for both inputs and outputs.

As with intensive and extensive farms, there was considerable evidence of the influence of physical resources upon intermediate farm systems. For example, **Farm D's** use of an Autumn calving pattern was influenced by local geography and climate:

"Generally in a valley like this we dry up in August ... So we've got less grass about this time of year [July], so sometimes cows have to be in during the day or night to get feed. But then in the Spring, if you've got the cows calved earlier [i.e. in the Autumn] there's more decrease in lactation, [and] they can make better use of grass."

Farmer B also provided a clear example of the influence of physical resources upon his decision to adopt an approach halfway between a grazed and a housed system:

"We try and turn out [graze] as early as we can, but in the climate that we've got – with 17 inches of rainfall, and an altitude of 600 to 900 feet up here – we tend to get out in the first week

¹⁶⁹ A spread plate distributes slurry across the surface of the ground

in April ... If we've no grass, we'll bring them in. It's also the weather, the climate really. It just ends up making too much mess, we'll have to bring them in 'cause it doesn't dry out that much at that time of year. That's one of the reasons ... why we're on a cross between the two systems ... If we put our cows out during the winter it's just too wet and they'd plough most of the fields up... So that's one of the main reasons why we don't have the have a grazed system all the time..."

Farm C showed similar interactions between the available physical resources and the selected (grazing) technologies on the farm, which interacted further with the farm's approach to breeding (operating a 'flying herd' – i.e. purchasing heifers – rather than rearing replacement cows on the farm):

"We're in marginal land here, we have half the farm is croppable, or grass croppable, I should say... half the farm is pretty much grazing, predominantly ... we cut [grass] where we can, and we keep improving the land so we can cut more, but there is a certain element that is grazeable only ... So we can't really cut it. We need to graze it. We don't have youngstock [as we operate a flying herd], so it makes sense that the cows go out and eat the grass."

In the cases described above, interactions between technologies and available physical resources were also supported by farmers' mindsets or technological frames. Indeed, **Farmer D** suggested that such factors might play a larger role in influencing farmers' approaches than constraints in physical resources:

*"I can't speak for [other farmers] but I wonder how much of that is restriction of the asset [i.e. land] or restriction of the mind ... I mean, everything I'm telling you supports what we're doing, **because** we're doing it. So to consider something else, you've got to get your head right round that and think somewhere different ... very often people say, 'I can't possibly do that because X, Y and Z', but what they're saying is 'I can't possibly do that because I can't think of a different way'..."*

Many of the farmers interviewed displayed a clear personal preference for grazing, for at least some of the year. As **Farmer B** reported: "I'm more of a grazing type person ... Personally I wouldn't like cows to be in all year round. That's my personal preference". Meanwhile, **Farmer C's** personal beliefs about the 'right' way to farm appeared to mirror his "middle road" approach:

"I like to see cows at grass. I think it's a big part of ... the 'feel good' factor in the job ... [But] where cows are grazed for long periods throughout the year, I see welfare issues there. Some guys are keeping them out in terrible weather, up to their knees in shit ... I wouldn't want to keep cows like that..."

Similarly, **Farmer D** maintained that, having operated both extensive and intensive models:

"[On] the very extensive [model]... we were just killing cows. It just didn't sit all that well with what you were doing... I don't like high intensive systems, personally ... one of our core values

is care, we care for our cows as best we can, we make them produce milk naturally. It's not about forcing them and looking at them as machines, just as business-generating things... That's the ethos that I work under. If I was forced to change from that, I probably wouldn't do it."

In the case of **Farm C**, the farmer's beliefs – and the interaction between these and the technologies used on the farm – related not only to the available physical resources but also to the farmer's values regarding his preferred lifestyle and its relationship with those physical resources:

"We're very fond of the appearance and the 'hill farm' nature of the traditional buildings [here]... [and we're] little bit stuck with how the land lies to expand massively ... I've got friends who're selling a lot of milk from one farm and are progressing, and really pushing on with milk sales, and they've gone down that road of housing the cows, and then you milk them three times a day with a big rotary parlour... It doesn't just fit in with the fit of this farm ... I like living here. ... It's a nice farm. I wouldn't want to move. And I wouldn't want to build up anything and spoil it ... I wouldn't want to expand at the expense of the pleasantness of the farm ... Some people expand for necessity, whether they do it for the need to generate cash to stay in business. Or some guys do it for a mission to milk 1,000 cows. I don't want to milk 1,000 cows ... if I can't have a good living off 500 I should be investing elsewhere in other things."

The importance of 'lifestyle' to the farmer was reminiscent of extensive **Farms G and P**, (**Chapter 8**), albeit he was measuring quality of life in terms of his physical surroundings, whereas **Farmers G and P** were measuring quality of life in terms of the labour demands of the job.

The interaction between technologies and labour resources was also particularly pronounced on intermediate farms, notably on those farms operating smaller herds.¹⁷⁰ For example, **Farmer J's** (herd size 120 cows) decision to install robots was influenced by a shortage of labour resources (similar to **Farmer I**, **Chapter 7**).

In the case of **Farm E** (herd size 180) interactions between technologies and labour resources were mediated by other, physical, resources, as changes in milking frequency were driven by labour shortages resulting from the farm's urban location:

"We used to be a three times a day system ... until ... about six years ago when we had serious limitations in labour. We are quite an urban farm and you struggle to get people that want to go into farming. So from that point we decided to go back to twice a day. The cows on a three times a day system were 10,000 plus litres yielding ... now we're more like 8,200 on average."

¹⁷⁰ Intermediate farms, compared with intensive and extensive farms, had smaller herds. The mean herd size for the whole sample was 200.78 cows: 248.07 for intensive farms, 147.94 for intermediate farms, and 228.44 for extensive farms.

In addition to the influence of limitations in the availability of labour upon production models, there was also a trend amongst intermediate farms towards the reduction of labour input costs, with such reductions influencing decision making regarding the adoption of technologies.

Farmer N explained that, alongside a reduction in herd size had from 330 to 165-175 cows, functions on the farm had been increasingly contracted out to third parties:

"We contract most [functions]... silaging [and] emptying the lagoon is contracted out. Fertilizer's already contracted out and spraying... so we just tend to milk ... [in] MMB days, with 330 cows, we did our own silage. We never had any contractors in. We did everything ... We're [now] using more compounds and blends produced by others ... the switch over to blends has been more of a cash flow issue ..."

Although considering milking robots, to further reduce labour costs, it was clear that the way that **Farmer N** framed the dairy farming problem was influenced by potential changes in future buyer demands, which were influenced in turn by changing public perceptions about dairy farming:

"I am a bit concerned of the public's perception of dairy cows. I think we're just not far from people wanting free-range cows. That's been probably at the back of my mind against robots. ... I think there could be a huge swing away from housed animals..."

Farmer H, with a herd of 150 cows, explained how a desire to reduce labour costs had influenced his decision to move from an even smaller, more intensively farmed herd towards his current system:

"Over about a six-year period ending a couple of years ago we went through and basically rebuilt the whole farm on its existing site ... [and] we thought that, for the amount of effort we put into a hundred cows, we could actually look after a hundred and fifty... we thought 'we're actually chasing our tails all the time here and we could be bigger and produce more milk and do it for less money' ..."

A key element of this change was the replacement of an old milking parlour that was "slow and unpleasant to work in". However, the farmer also made fundamental changes to his feeding approach in order to reduce labour requirements:

"In 1994... We were... a proper family farm, with a Keenan feeder [i.e. feeding a TMR]. We spent two hours a day putting feed out every day of the year. And they were giving about 8,200 / 8,300 litres of not quite such good quality milk, and consuming about 2.25 – 2.4 tonnes of bought in straights [concentrates]¹⁷¹... But we've made life simpler. They're not fed a TMR any more, the cake goes in the bottom of the feed trough and the silage goes on top, so it's a twenty five minute job rather than a two hour job..."

¹⁷¹ <https://dairy.ahdb.org.uk/technical-information/feeding/concentrate-feeds/#Straights>

Farmer D, by comparison, explained how rising labour costs had influenced his decision to *expand* the herd over time, in the pursuit of economies of scale:

"The problem is if you've got certain overheads in the business, they invariably go up; wages go up each year ... So unless you're moving the business forward, it's quite hard to cover the cost of that ever-increasing overhead... steadily increasing [the herd size] just keeps you the right side, it keeps you ahead on that cost basis ... So that's the reason for expanding."

In expanding his herd (from 350 in the 1990s to 480 at the time of interview, with plans to increase to 550), **Farmer D** also revealed significant interactions between labour resources (and the knowledge and skills embedded in his staff) and technologies (in this case, herd size and fertility). As the herd had expanded – employing more staff – the farmer had found the need to introduce heat detection collars (which had reduced the calving interval “from 430 / 440 to 390” days), in response to a reverse salient (namely, newly-introduced staff lacked the necessary knowledge or skills to detect heat and therefore the calving interval had increased, as heat detection fell behind the performance of the rest of the system):

*"Certainly as you get a bigger herd, you put more people in it, so we've got six or seven people in the herd now as opposed to three or four, some years ago. Particularly on a large herd, to get people to identify bulling cows accurately, it's quite difficult... and we are employing quite a few people in the farm now who've never seen a cow when they arrive ... Whereas the guys who've been here for years, they can see a bulling cow before it's bulling. But I think actually a sort of crossover between technology and psychology is that **technology is eliminating a lot of the stockmanship skills that take years to build up**, so there's quite a benefit in technology ... But you've still got to get the people using technology right..."* (emphasis added)

A positive feedback effect resulting from the introduction of such technologies was notable, as the farmer implied that the introduction of collars was effectively ‘deskilling’ the workforce (in terms of heat detection) and therefore requiring the continued use of collars. This could be characterised as a complementary effect between the collars and the labour force’s lack of skills.

Similar to interactions between technologies and physical resources (above), interactions between technologies and labour resources were also mediated by actors and institutions (chiefly, actors’ beliefs, which influenced their ‘technological frames’). For example, **Farmer J** – who had explained that his system offered flexibility in terms of feeding approach (see 9.1) such that he could easily “swing back the other way” from feeding predominantly forage towards feeding predominantly concentrates – provided evidence that the flexibility of his system was supported by a flexibility in the farmers’ beliefs about the ‘right’ way to farm:

"I'm driven by profit ... I'm only in it for business ... and therefore I try and run the system as profitably as possible ... if I couldn't make money out of it, I'd give up ... I don't mind cow s... I quite enjoy working with cows ... but they are a means to me getting money, and that's all I do it

for. What motivates me is making money, and I'm always constantly challenging the system to make more money, and I will follow the way to make money..." (emphasis added)

In this case, the farmer appeared to frame the 'problem' of dairy farming almost exclusively in terms of how to extract the maximum financial return from the enterprise. Of course, while all of the farmers interviewed, as business owners, were financially motivated to some degree, not all farmers framed the problem of dairy farming, or the solutions to that problem, in terms so tightly centred upon the profit motive. Instead, their frames were more often contained other cognitive and normative dimensions, including considerations of animal welfare, lifestyle or aesthetics (e.g. **Farmer C**, below, 9.3.3.1). **Farmer D**, for example, suggested that:

"It always made sense to produce as much milk as possible within the realms of the economics of unit cost. But it's a case of how you do it. If you do it by stuffing your cows full of food, you're gonna drive problems into your business, and welfare, et cetera, et cetera."

Some farmers also revealed the existence of normative rules related to their inheritance of the business, in particular around the use of specific breeds that had been used by previous generations. **Farmer E**, for example, described a personal / emotional attachment to the Shorthorn cows that had been kept on the farm for several generations, which was exerting an influence on her current breeding decisions.¹⁷² While the farmer was being driven to reduce the number of Shorthorns in the herd in order to improve yield and efficiency (see below 9.3), she reported that:

"All our cows are descended back to my grandfather and his father and probably his father – and just to suddenly give up on them doesn't seem right. So there's that mental barrier ... which is bad business, but it's still something that mentally we've got to overcome..."

Moreover, the farmer's attachment to her current system extended beyond breeding technologies. She also suggested that changing pattern represented a significant 'mental change':

"We don't manage [the Shorthorns and Holsteins] massively differently [from each other]. [But] we could ... the Shorthorns would be suited to Spring calving and milk at grass ... and then we could calve the black and whites in the Autumn and they would be on a more expensive system. So we've looked at it... it's just a very big mental change... we calve all year round and it's the system I'm used to ..."

¹⁷² NB: The farmer was also influenced to keep Shorthorns by more 'formal' institutions ("We have been influenced to keep more Shorthorns lately because we are on an environmental scheme, which encourages us to keep native breeds").

Farmer N made similar observations regarding his decision to continue dairying in spite of receiving a very low price for his milk (see below, **9.3.1.2**):

“The herd goes back ... almost 100 years. It does make you hang on to things when they are not profitable, because I think most people have got out this last 12 months... family farms... It's more than just a business. And working with animals is more than just a business how you do it. I don't think you can do dairy and just treat it as a purely financial thing to do.”

9.3 The Influence of Buyer Power

This section considers the influence of buyer power upon the patterns of change outlined above (**9.1 – 9.2**). As with **Chapters 7 and 8**, this analysis is structured by reference to buyer demands relating to:

- Security of supply (**9.3.1**)
- Product characteristics¹⁷³ (**9.3.2**)
- Production characteristics (**9.3.3**)

Within each of these sections the analysis considers the mechanisms through which buyers seek to achieve compliance with these demands (i.e. conditions of value chain governance, including sanctions and trust).

9.3.1 Security of Supply

Intermediate farms provided examples of milk buyers successfully influencing farms, with regards to the security of supply, through the use of the following sanctions¹⁷⁴ (see also above, **5.2.6**):

- **The power to exclude**
- **Base prices for milk (and bonuses¹⁷⁵ for overproduction)**
- **A / B pricing**
- **Seasonality payments**

¹⁷³ NB: As with the intensive and extensive farms reviewed in **Chapters 7 and 8**, intermediate farms provided no evidence of farmers responding (or not) to food hygiene and safety standards above those required by statutory minima, hence the following discussion does not include a section dedicated to these.

¹⁷⁴ NB: There was no evidence of seasonality payments influencing the approaches of the extensive farms visited, hence the following discussion does not include a section dedicated to this.

¹⁷⁵ Bonuses for overproduction are considered concurrently with base prices because, in the example used (**Farm C**), the influence of buyer demands on the farmer (and the broader sector) was the result of the interplay between base prices and bonuses, see further below.

9.3.1.1 The Power to Exclude

In addition to 'direct' influences of buyer power and demands upon farms, there was evidence of intermediate farms responding to broader sector-level market movements and signals (i.e. 'indirect' influences of buyer power). These may be grouped broadly under the heading of 'the power to exclude' and relate, variously, to farmers' status as 'price takers' and to their reliance upon buyers due to the lack of availability of alternative contracts (see, 5.2.6).

For example, **Farmer C** explained that he had switched supplier from Milk Marque to Wiseman in the mid-1990s when it became apparent that Wiseman was expanding its market share and that it might therefore dominate the processing regional market:

"The catalyst was when Wiseman dairies came to Manchester, and they paid some ex-MMB guy who I was good friends with, and he came and he targeted bigger farmers in this [area] ... we were on a main route ... I just felt, these guys are coming and bringing superdairying ... They're gonna get the milk."

Put differently, this was not a direct response to explicit sanctions applied by buyers to their existing suppliers. Instead, the farmer had switched supplier in anticipation of a sector-level shift in the balance of power within the processing market (i.e. an expectation effect associated with concentration in the processor market, discussed in 5.2.2) and due to a desire for the relative security associated with belonging to a large milk pool operated by a powerful market player (resulting from a fear of being left without a buyer or with an inferior contract in the event of the anticipated market shifts).

The attractiveness of supplying a milk buyer with a strong market position – and the reliance of farmers on buyers – was highlighted by the experience of **Farmer N**:

"Our previous dairy supplier went bankrupt ... just over 10 years ago. I actually had three bankruptcies on me within 12 months ... We lost £50,000 from the business, which really hurt, when the price wasn't particularly good anyway."

Farmer E's experience as an aligned producer offered further evidence of farms' reliance on buyers, with farms effectively being passed from one processor to another, with little apparent control over their ultimate destination. Although **Farm C** suggested that one of the benefits of an aligned contract, from the farmers' perspective, is that the processor "becomes a contract processor" (see below 9.3.1.2), the drawback of this is that, because supermarkets may re-tender processing contracts, the farmer relinquishes control over the decision of who processes their milk. **Farmer E** explained:

*"Sainsbury's has retendered for their milk ... originally the bulk of it was coming from Muller and Arla ... [but] they have played the processors off against one another... [and] they've also been influenced by the latest policy from Welsh Government, which is to encourage more processing in Wales. So ... our milk, which was going over the border to England and then coming back to Wales ... is now going up to Wrexham – which is three hours away – to a Welsh processor. But it's a little bit worrying for me, because we have always been with Unigate, Dairy Crest and now Muller ... and now our aligned [buyer] is saying 'right, you know, you are going to **this one** now'."*

This practice of 'playing processors off against one another' stood in contrast to the relatively longer term supermarket-processor relationships within the value chains of Waitrose and Marks & Spencer (see 8.3.1.1), and suggests that the value chains of large and small supermarkets may have distinctive characteristics. The farmer reported feeling insecure about the loss of control that this arrangement involved, and the risk that, were she to lose her aligned contract, she might be left without a contract with a local processor:

"They [Sainsbury's] have given us a lot over the years, we trust that relationship, and we are just going to have to go with the flow and hope ... We are just taking it on goodwill that Sainsbury's are going to look after us and that it will be OK."

Although the above cases do not provide examples of the (direct) influence of buyer demands upon *specific* aspects of production, they do highlight the degree of reliance that farmers may have upon powerful buyers (such as supermarkets), which may in turn influence indirectly the technological decisions that such farmers make (in order to secure or retain their contracts). Moreover, the fact that farmers appear to be prepared in some cases to relinquish considerable control to buyers highlights *either* the degree of trust within such relationships, *and / or* the lack of alternative contracts offering competitive milk prices.

Indeed, despite the potential loss of control associated with being an aligned producer, the demand for such contracts (perhaps due to their higher, more stable price, see below) was clear, once again demonstrating the *pervasive* effect of such contracts (see 7.3.3.1), influencing farms both inside and *outside* of the supplier pool. As **Farmer D** recalls:

"I wrote to [Dairy Crest] almost at the very beginning [when supermarket contracts were first introduced], saying I'd be interested in a contract with a supermarket should one come up."

Further evidence of this indirect influence of supermarkets was provided by **Farmer C**, who explained that Tesco operates a 'waiting list' of farms hoping to secure the contracts of the worst-performing farms that Tesco excludes from the pool (7.3.3.1). This supports the finding that practices developed and promoted within aligned pools (as a result of benchmarking) have indirectly influenced some farmers' practices across the sector as a whole, through expectation

and co-ordination effects (see 7.3.3.1, **Farmer O**, who was “trying our best to be what they [Tesco] wanted anyway”). Similarly, **Farmer N**, who was hopeful of securing an aligned contract, explained that, in order to do so, he would “jump through whatever hoops we were given”.

9.3.1.2 Base Prices for Milk (and Bonuses for Overproduction)

Intermediate farms provided clear evidence of the influence of sanctions imposed by buyers, in the form of milk prices. As with intensive and extensive farms, high prices encouraged intermediate farms – such as **Farm N** – to expand farms to expand and low milk prices also encouraged intermediate farms – again, **Farm N** – to scale back in herd size (cf. 7.3.1.3).

Reductions in base prices, implying a buyer demand for reduced volume, also influenced intermediate farms to reduce yields per cow, often through changes in the deployment of feed technologies (similar to intensive **Farm I**, 7.3.1.1). **Farmer B’s** experience was typical:

“[We’re on] 8,100 [litres per cow per annum] at the moment ... Going back a year / 18 months ... we peaked at about 8,400 litres and then ... with the milk price the way it is, we're trying to get more out of the forage now. And then it's just dropped us back a little bit on litres, but with the way the milk prices are it's a more profitable way to do it at the moment...”

Similarly, **Farmer J’s** approach to feeding was strongly influenced by the current prices available for milk (see further below, 9.3.1.3):

“We could chuck more concentrates in and push the yield up but I don’t think we’d make any more money ... I think we’d make less... so that’s why we’re going towards feeding more forage and less concentrates ... Last year we had a rethink about what the marginal litre was costing us ... [and] we really dramatically cut back the concentrate feed.”

As well as such ‘direct’ effects, the interviews also provided an example of ‘indirect’ or sector-level effects similar to those outlined already (9.3.1.1), resulting from the manipulation of prices by buyers with considerable market power. **Farmer C** recalled that he had decided to switch from supplying his processor, Wiseman, due to the low base prices it had been paying. While this appears, initially, as an example of a ‘failure’ of buyer power (section 9.4 below), the ensuing events and actions suggest, over the longer run, the reverse. **Farmer C** explained:

“I had a bit of a falling out [with Wiseman] around ... 2002 ... They were ... dropping the price down ... blaming currency, commodities, whatever ... a lot of farmers became unhappy ... I was disgruntled. I handed my notice in.”

With many of its suppliers threatening similar action, the farmer recalled that Wiseman had responded by offering farmers a bonus of 4ppl for providing additional milk, enabling it to

retain many disgruntled farmers, as well as to attract new farmers. The net result, the farmer recalled, was overproduction in the market, precipitating a slump in the milk price at the sector level:

"Basically, the market collapsed ... They took these extra farmers on. There was an oversupply ... and they just bombed ... There was nowhere to sell it [the milk]..."

While the above account implies a degree of bargaining power on the part of the farmers with regards to short-term price movements, over the longer-term the net result was, ultimately, a return to low prices. Significantly, the broader effects of overproduction upon the market appeared to have an influence on the farmer's attempted switch to an alternative buyer. He recalled:

"We had about three or four months selling to First Milk, which was [merging] with Dairy Farmers of Britain ... and it went tits up. It was a mess. I said [to Wiseman], 'look I need to come back' ... It were breaking me. I said: 'I've made the biggest mistake to my business'. They were all laughing, taking the piss, you know ... the whole deal cost me 50 grand ... but ... I begged to go back ... I was losing literally 10 or 15 grand a month ... [it was] a very strong lesson to learn. We were very small fry ... You are so soon shafted by these big companies ... They can always put you in your place ... Obviously ... what you want [is] security ... and that you're going to get paid, and to work on the factors that you can influence, like your own job."

The volatility of a discretionary price, and the insecurity that this implied for **Farmer C**, stood in contrast to his subsequent, aligned, contract to supply Tesco (the high, stable Tesco price relative to prices paid under non-aligned contracts was illustrated in **Chapter 7, Figure 7a**). The farmer explained how the stability of that price – and the continuity, reliability and predictability it provided – had given him the confidence to plan and invest:

"The market has no mercy ... the milk purchaser is a massive, massive area, where you need security and commitment. And we're very fortunate, we've got an aligned contract with Tesco, who I'm quite involved with ... and that's seen us through these difficult periods. It's set us on a different trajectory because ... about nine years ago we were in a similar situation the farmers have been in now, and my faith had about left for me investing in the farm ... but then when the Tesco job came up, we got this guaranteed structure on [a] fully cost of production [basis]. You got an idea of where it was going, and ... it gave us a lot of security, and a lot of confidence. We've since then re-invested in the facilities the best we can."

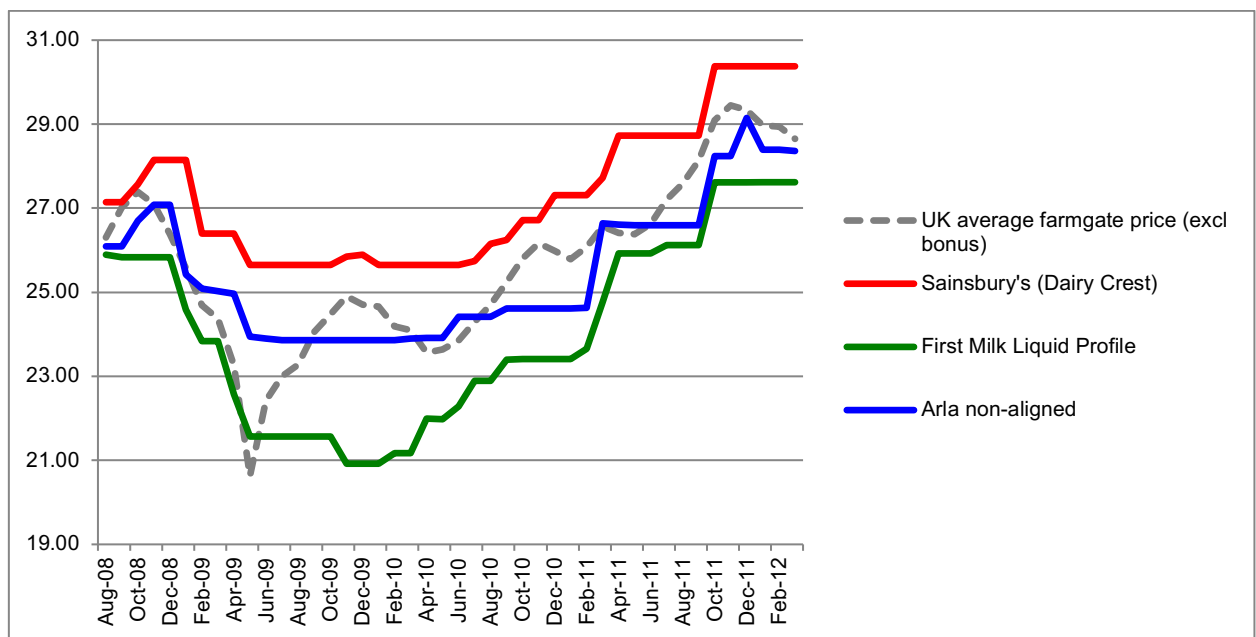
Such investments would, further, result in investment effects, introducing stability into farms' socio-technical systems. **Farmer E**, who had an aligned contract to supply Sainsbury's, reported a similar effect of price stability upon the farm's ability to invest:

"We became an aligned producer in 2007 ... and we had a lot more guarantees then on income that was coming in ... 18 months ago we moved into our new milking parlour. That's the biggest investment that's been made on the farm, other than the slurry tower, in the last forty years. It replaced a forty-year-old parlour that was falling apart ... We got to the point with it

where we thought 'this parlour is so old we are either going to have to replace it or get out of dairy'. Because of our contract we replaced it, because we were secure, and we survived this nightmare that everybody else has been through."

The price paid by Sainsbury's (through Dairy Crest), relative to prices available under non-aligned contracts, is demonstrated by comparing prices over a 44-month period between August 2008 and March 2012. Over that period, the Sainsbury's (Dairy Crest) milk price was high relative to non-aligned prices, paying an average of 27.29ppl, compared with 24.04ppl and 25.5ppl paid under the First Milk and Arla contracts, respectively (see **Figure 9a**, albeit it was not as high or as stable as the Tesco or Waitrose prices, see **Figures 7a** and **8a**). Over the same period, the Sainsbury's (Dairy Crest) price changed 15 times (or every 2.93 months) compared with 17 times (or every 2.59 months) and 23 times (or every 1.91 months) under the First Milk and Arla contracts, respectively. The variance in the Sainsbury's price over the period was 2.7ppl, compared with 5.08ppl (First Milk), demonstrating its greater stability, although the Arla price (while lower) was more stable, with a variance of 2.61ppl.

Figure 9a: Volatility of Milk Prices in Aligned vs Non-aligned Contracts



Source: Author (adapted from AHDB data¹⁷⁶)

Farmer E provided further evidence of the influence of this stable price upon Sainsbury's producers. Just as farmers within the Waitrose pool have "grown enormously" "because of the

¹⁷⁶ <https://dairy.ahdb.org.uk/resources-library/market-information/milk-prices-contracts/league-table-new-profile/>; <https://dairy.ahdb.org.uk/resources-library/market-information/milk-prices-contracts/uk-farmgate-milk-prices/>

confidence [the Waitrose contract has] given [them]" (8.3.1.1), so too the Sainsbury's pool has reduced in farmer numbers while increasing in milk output:

"When we first became members of Sainsbury's there were 333 of us in the group... by purely ... natural shedding – so I'm told – there are now 272 of us, maybe... 273... [and] we're all doing well, so the pool is producing more milk and Sainsbury's is now buying more than it sells..."

By contrast to the high, stable base price paid under aligned contracts – and the opportunities this offered for planning and investment (outlined above), there was evidence that low, volatile, discretionary (non-aligned) prices inhibited investment (in addition to encouraging a reduction in output, as already observed). **Farmer N** explained:

"We are currently on 18.9ppl, [and] we are going to get 2p increase at the end of this month, at the beginning of August. I think my costs [of production] are 27p, [so] I think we're losing 7,000 quid a month at the moment, which has a big bearing on the future, and this last 18 months had a big bearing on investment..."

The influence of such low prices upon conditions of value chain trust was widely evident amongst non-aligned farmers, and echoed the 'frustration' reported by intensive **Farmer I** (7.4.3). For example, the low milk price that **Farmer N** had been receiving was not only hindering potential investment in milking robots but, in the absence of an improvement in prices, the farmer was considering exiting the dairy farming sector:

*"We've gone from really being a reasonable sized producer (we had 330 cows) to a small producer (we've got 170) in 15 years ... probably the only way [forward] is [to introduce] robotic [milking] ... to cut down costs even more. [But] before you get on route you need **confidence** that you're not going to hit another lull like we did ... If we **did** get an aligned contract ... I think that would be fair route to go down ... We are looking for better contracts... If we don't get one ... I think we may actually sell the herd ... an aligned [contract] with Tesco would've given us another £130,000 this year... We would ... for five to 10p a litre extra, which it [the Tesco price] is at the moment ... we could have an extra member of staff ... you could invest in machinery, invest in health..."*

The importance of a high, stable price to the continued operation of intermediate farms was therefore clearly evident. Indeed, similar to intensive **Farm F** (7.3.1.1), **Farmer D** suggested that, were it not for his aligned contract, he would probably no longer be in the dairy farming business, or would have to significantly scale back production in order to remain viable:

"If we were on an open market price, I don't think we'd be dairy farming today ... We would have to be doing things different than we are now. We would be losing around £400,000 a year if we were doing things as we are now on a non-aligned contract ... A herd like us – 4 to 500 cows – if you had the ability in times of low prices to take that back to maybe 100, 180 cows, and just run that on sort of one-man, very tight [system] ... you're still gonna lose money, but you're not gonna lose that much money... And then scale it back up when times are good ... The only way

you could do that is to have an open herd. You wouldn't be able to do that with a closed herd, which we are, and obviously a closed herd has all the benefits of disease prevention ..."

There was, therefore, evidence that the stability of prices paid under aligned contracts not only supported the ability to invest, but had also contributed towards strong conditions of trust within aligned value chains, providing a degree of predictability and continuity that was both enabled by and had enabled long relationships. Sainsbury's supplier, **Farmer D**, believed that supermarkets were consciously and actively seeking to develop such conditions:

"The supermarkets ... have sort of grown up a little bit with their relationship with their suppliers. It's not quite so cutthroat... 'Buy it as cheap as we can, sod you' ... I think they've realised a need for longevity. I'm not saying that's true of all supermarkets, there's certainly a thing I'm noticing with the supermarket we're with."

However, this claim was not without [light-hearted] qualification, as he added:

"That said, tomorrow they might completely throw that ... out of the window! [laughs] Then we'd be having a different conversation. But certainly since the time we've been working with Sainsbury's, they've been really fair, particularly through all this milk crisis..."

Just as it was evident that farmers desired long-term relationships with supermarkets, ostensibly to benefit from the high, stable price, it was also clear that supermarkets wanted farmers to demonstrate consistent long term performance to high standards. For example, **Farmer E** explained that she was awarded a supermarket contract, in part, to the fact that she could demonstrate continuity in her relationship with her previous processor and a consistent level production profile:

"Dairy Crest started supplying Sainsbury's, Sainsbury's said 'we want suppliers that have been with us a long time', they looked back through the records [and] found us"

Similarly **Farmer C** explained that invitation to be a 'farmer champion' for the Tesco Sustainable Dairy Group (TSDG), when it was first established, was the result of a long term personal relationship with one of the individuals responsible for establishing the TSDG:

"I was still friendly with [the individual]. Although we'd had this tiff, if you like, we got back and what have you. I think there's some mutual respect, friendship, whatever."

Perhaps understandably, non-aligned producers were more openly sceptical of the 'fairness' of the aligned value chain model. **Farmer N**, although actively seeking an aligned contract at the time of interview, suggested that:

"[Tesco] could source that milk for ... millions of pounds cheaper ... if they wished ... their PR guys are obviously persuading the buyers it's worth it, and ... once the PR guys can't persuade them that the benefits are there, the price they're paying may just collapse."

Farmer J – who would also have welcomed an aligned contract, and had no reservations about the requirement to share unaudited accounts data with supermarkets – expressed similar views. Indeed, although farmers within this study were almost universal in their distrust of discretionary approaches to determining base milk prices, **Farmer J** was equally sceptical of the future sustainability of using cost of production data as a method of base price calculation, and therefore questioned not only the fairness of such models, but also the continuity, reliability and predictability of their operation (see further below, 9.3.3.1):

"[Aligned contracts] have their appeal but ... the likes of Tesco and Sainsbury's will have to eventually hammer back on this, because they can't keep on paying so much more for their milk ... Tesco and Sainsbury's are making an inefficient group of farmers ... the more inefficient they get, the more Tesco pay them ... so I'm sure Tesco's now see the error of their ways... [However, I would accept a Tesco contract because] ... we have now driven our costs down to about 22-23ppl ... if I was selling to Tesco I would be on 29ppl ... because I am driven by driving my costs down [while] Tesco farmers aren't driven by driving their costs down. So why wouldn't I want to go in there? I'd probably then become very inefficient and ease my way back up to 29p, because that's what happens. Give a farmer some money and he will spend it."

For **Farmer C**, however, the transparency of the price calculation mechanism in aligned contracts (as compared with the discretionary pricing available under many non-aligned contracts) was fundamental to the creation of conditions of trust within aligned value chains:

"[When the Tesco aligned pool was first established] Some farmers were enraged, [because] part of the deal was, to set your cost of production, you'd give your figures ... [but] I thought 'go with it' ... and a lot of scepticism has been turned into ... a built up trusting relationship ... By being aligned, we're protected. The difference is ... we're protected from the other market forces that affect Muller's pooled price, including their costs ... They stipulate, that's the price the farmer gets, so the processor becomes a contract processor... he's no longer skimming whatever he wants ... that's the big benefit."

Once again, just as the strength of sanctions within aligned chains relied upon the existence of relatively weaker sanctions across the sector (7.3), so too were conditions of trust in aligned chains regarded as 'strong' relative to conditions within non-aligned value chains.

Finally, in addition to enabling farms to invest, the price stability afforded by aligned contracts was contributing to inertia and path dependence in the case of **Farm E**, inhibiting a move to alternative approaches to producing and marketing milk, such as on-site processing:

"Whether our future is as your standard dairy farm or whether, because the urban area is closing around us, I might go on to more local supply ... we'd process on farm possibly ... but

our contract is so good at the minute and so secure, you worry about giving that up ... So perhaps looking ahead I would like to think we would go into on-farm processing and link in with the local area and we would probably become more of an open farm, and perhaps our money wouldn't come so much from milk, it would come from the fact that we are open and we are an attraction..."

The farmer was therefore discouraged from diversifying her business into the direct marketing of milk within local markets, for fear that such a move would conflict with her current contractual arrangements with Sainsbury's. As well as stabilising the farm socio-technical system, this therefore served to further *compound* the farmer's reliance upon Sainsbury's, restricting her to supplying a single, large, buyer as opposed to negotiating with several buyers.

9.3.1.3 A/B Pricing

There was considerable evidence of the influence of A/B pricing on the intermediate farms analysed, in particular upon non-aligned farms.

Farm N's milk buyer had introduced A/B pricing in April 2015, with farmers receiving a 'B' price 5ppl less than the standard 'A' price for any milk delivered 5% above or below their 12-month rolling average production, except during the months of April, May and June when the 'B' price was paid only for milk above 5% of 12-month rolling average production, with the 'B' price being calculated as "the difference between the average A Litre price to our farmer suppliers and the net spot price obtained for milk during April, May and June" (see **Appendix 9F**).

The farmer explained that, to avoid being penalised for underproduction, he would probably increase feed per cow, rather than expand herd size:

"I don't want to buy cows in ... we've got closed herd status, and have since 1998. I wouldn't want to risk buying something in ... so we're just going to have to take that knock ... [But] if yields are looking low ... We'd look at it financially and if it's worth feeding a bit more to get that, we would do that..."

He also highlighted his relative lack of power, and complete reliance upon the processor, which served as an indicator of low levels of trust within this value chain:

"The dairy has had a whip hand for 18 months now, which is most annoying and really we had to just take it ... There was a so-called negotiation but as a matter of fact we didn't have any strength whatsoever. There was no other dairy we could have gone to. That is a weakness always."

Farmer J, under the influence of A/B pricing, had reduced his herd size and his concentrate use:

Our milk buyer was First Milk and ... they brought in their A and B [contract] and ... 90% of your average of your milk in any particular month [would receive the 'A' price] ... and their A price is poor, and their B price is pathetic ... so last year ... we basically chopped out [sold] about 7% of our cows... and we also changed the system ... to make better use of the quality forages we were using ... So we fed more forage, less concentrates, and milked less cows ... milk yields stayed roughly the same, but our feed rate dropped to 0.25 of a kilo of concentrates per litre, last year¹⁷⁷..."

Ultimately, the farmer had switched processor, to Wyke Farms, which also operated an A/B pricing scheme, albeit one that corresponds more closely with the farm's system, allowing the farmer to increase the herd size back to its previous level. Whereas 'A' litres under the First Milk contract were determined to be 90% of the farmer's production for a particular month, by reference to the farm's average historic production for that particular month, the Wyke Farms 'A' litres were determined to be 100% of the farmer's daily production volumes (within a +/- 5% tolerance), calculated as the total number of litres produced over a two-year reference period, divided by 730 (days) (see **Appendix 9G**). The contract therefore didn't penalise the farm to the same extent for seasonal fluctuations in yield resulting from the farm's Autumn-calving model.

"When you're drifting into B milk, you are only risking a smaller proportion of your milk [under the Wyke contract] ... So in your low milk months – because we are seasonal calving, we're July, August, September, October calvers – you are never going to be in 'B' milk ... and our low months tend to be the months that would have low milk prices (the Spring) ... but we do produce more in the Autumn, and therefore our milk will go into the 'B' milk band in the Autumn, but in average years the 'B' milk is worth more than the 'A' milk at that point and so we will get a bonus for producing it... [with] the First Milk one ... you couldn't avoid [being penalised] really because they averaged it on a monthly basis, not a twelve monthly basis."

By contrast, **Farmer D**, supplying Sainsbury's, suggested that the introduction of A/B pricing had given him cause to reconsider expansion, but had had limited influence on his approach:

"We were looking at expanding this year, but I thought we'd put it back a year [as a result of the new limits on production introduced by Sainsbury's]."

9.3.1.4 Seasonality Payments / Penalties

Seasonality requirements influenced intermediate farms, albeit to a lesser extent than intensive farms (many of which calved all year round) and those extensive farms that operated Spring calving approaches, which were often penalised for higher production in the Spring. Instead,

¹⁷⁷ Feed rate is a measure of units of feed inputs used per unit of milk output, typically measured in kg / litre. In this case, 0.25kg of concentrate feed is used for each litre of milk produced.

intermediate farms (e.g **Farm H** and **Farm B**) often opted for Autumn calving, enabling them to benefit from Autumn bonuses in non-aligned contracts

For example, **Farm H** moved from all year calving to Autumn calving to secure seasonality bonuses, a move that was enabled by the farm's relatively low production volumes per cow:

"It suits us financially because I get no Spring deductions on Arla's payment programme, but I get the Autumn bonuses, because in the Spring I'm below my average profile production, and in the Autumn of course I'm above it... The cows graze grass freshly calved and I don't find a problem with that. People keep saying you should only ... put stale milkers on there [to graze], but ... for their level of production, you know, seven and a half thousand litres that I'm doing, it pays ..."

Farmer B reported that his buyer had influenced his selection of calving pattern in a similar way:

"On the Arla contract we get penalised for producing Spring milk, so we're trying to hit the peaks in the winter now so we can have a good high base and we won't get penalised as much in the Spring ... One of the things is the milk buyer trying to drive us down more to the Autumn production milk."

There was evidence that supermarkets' preference for level annual milk production militated against the use of more extensive Spring-calving approaches amongst intermediate farms. In the words of aligned **Farmer D**:

"I think that an extensive system is very good. Because obviously if you've got a low unit cost production, you're more resilient anyway, to a low price. The downside of that is that your low cost of production tends to mean a really tight block of milk, generally in the Spring when it's less wanted. Sainsbury's wouldn't want to know you ... so they're buying what they want. And we're providing that, albeit at a higher cost of production than producing all your milk in that one shorter span of time."

Aligned farm **Farmer E** had been all year calving since before the MMB was dissolved (i.e. before she was supplying Sainsbury's, and suggested that "[calving pattern] is pretty much fully influenced by the buyer".

9.3.2 Product Characteristics

9.3.2.1 Sanctions/ Penalties for Constituents

Similar to intensive and extensive farms, there was evidence of contracts supporting farms' existing approaches to feeding cows. For example, **Farmer C** explained how his previous contract to supply Wiseman made sense as their system was set up to produce 'white water'. Elsewhere, **Farmer J** explained that his current contract, which rewarded the production of constituents was encouraging changes in his feeding approach"

9.3.3 Production Characteristics

Buyer demands regarding production characteristics were most notable within aligned value chains, in which supermarket buyers required the collection of considerable volumes of farm data for benchmarking purposes, in order to calculate production costs (in contracts in which the milk price was determined by reference to costs of production), and to monitor farm performance against animal welfare and environmental standards.

Buyers' efforts to influence the cost of production and welfare/environmental standards, respectively, are considered in greater detail in the sections below. However, at a general level, the enforced requirement for data collection corresponded well with some farms' progress towards existing goals, and was complementary to a trend within dairy farming towards increased data collection and analysis (whether around grass growth, the nutritional composition of feed, somatic cell counts, or antibiotics use; e.g. **Farmer F, Chapter 7; Farmer K, Chapter 8**). For example, one consequence of the increased data collection requirements in supermarket contracts was an improvement in the ability to secure grant funding. Again, **Farmer E** explained:

"We have just applied for a grant for housing ... [so] we can increase [cow] numbers. We have got through phase one... probably ... because of all the data we keep as aligned suppliers with Sainsbury's. So they require us to keep a lot of data, and applying for grants is suddenly a lot easier because I've got it all there: we know our carbon footprint, we know our cost of production and we know our performance figures and our welfare figures and everything else."

9.3.3.1 The Cost of Production (and the Threat of Exclusion)

Whereas non-aligned **Farmer J** had criticised aligned pools for "making an inefficient group of farmers" (see above, 9.3.1.2) and argued that cost of production pricing removed the incentive to improve efficiencies, aligned farmers, unsurprisingly, offered a different view. Many claimed that benchmarking and cost of production contracts had served to focus their minds upon seeking efficiency improvements, due to the threat of exclusion for poor performance. **Farmer C**, for example, explained how, as a result of being benchmarked against other Tesco producers, he was paying closer attention *both* upon increasing yields per cow and cutting costs:

"[It's] a combination of the two. Every Tesco supplier now ... The data is aggregated, but our own specific data's come back, and it's identified variable cost ... feeding, forage, vets, sundries, whatever [as an area of concern]. It's identified where you sit, where the average is, where the top 25% average is, and the average of the bottom 25%. So you can see there, at a glance, whether you're in the red, green, or amber."

The pressure on Tesco farmers to improve their performance relative to the rest of the aligned pool was potentially amplified by Tesco's 2015 review of its producer group, from which the supermarket concluded that it would in future serve notice upon the worst performing 5% of

producers, based upon a 'balanced scorecard' (see above 7.3.3.1). Exclusion, according to **Farmer C**, would be based on a "cumulative score" which takes into account a farm's performance in terms of 'quality', 'value', 'innovation' and 'service', bearing in mind its performance against Tesco's 'livestock code of practice'¹⁷⁸ and its carbon footprint ("which is directly relevant to your cost of production"), rather than being based purely on production costs in pence per litre. Whereas intensive systems (7.3.3.1) appeared uncertain about the influence of Tesco's review upon their systems, intermediate **Farmer C** appeared to be more sensitive to these developments (albeit he was intimately involved in the Tesco pool, having sat on the steering group that informed its creation, and served as one of the pool's 'farmer champions').

Farmer C said that he was initially awarded his Tesco contract by "luck ... I was definitely in the right place at the right time." However, he welcomed the fact that future membership of the group would be more selective, following the review, and the influence that such pressures would have on production approaches:

"The hiring and firing ... is the way it's going to go forward ... And as a group, we felt ... that just because you've inherited a Tesco contract ... that it [shouldn't] give you a right to that privilege ... You've got to earn it haven't you? So where there's a case that perhaps people aren't investing in the farm ... they're just taking the money, or they don't look after the cows as we've¹⁷⁹ prescribed, then ... you could lose your contract. They're making it more select, more competitive, so that the bottom 5% can be taken out... for the good of the group ... Competitiveness is good ... it's just forcing you to use best practice, that actually is benefiting you."

Further, his belief that 'competitiveness is good' provided evidence of a process of collective stabilisation and closure of frames within aligned pools (in which supermarkets encourage competition between farmers), and echoed the view of intensive aligned **Farmer O** (7.3.3.1), who had argued that "if some people are prepared to put in the effort to do better, why shouldn't they be rewarded?" This stood in contrast to farmers who had chosen to forgo their Tesco Direct contracts in favour of Arla co-operative membership (e.g. **Farmer B**, 9.3.3.1; **Farmer P**, 8.3.3). Indeed, **Farmer B** explained that the constant downward price pressure resulting from competition between farmers within aligned pools underpinned his decision:

*"Arla is always going to be there. Tesco's, you would have thought will probably be there, but they will always keep the costs down as well. So they are only going to pay on a cost of production. [But] with Arla ... hopefully if the milk prices get better we'll see the benefit of being with a **farmer-owned** company"*

¹⁷⁸ Smith et al 2012

¹⁷⁹ NB: **Farmer C** was a 'farmer champion' for Tesco

Farmer C added that underperforming farms within the Tesco pool would be “offered help” to reduce their cost of production:

“If you can see your feed costs are 3 pence higher than the average or the top 25%, the writing is on the wall isn’t it? And they [Tesco] can see that. So they’re obviously going to spend time and money now, through consultancy, on targeting those in the bottom 25% to say ‘either you are going to go, or are you going to improve?’.”

This provided evidence of co-ordination effects resulting from “technical assistance which flows along the chain” and “bilateral technology transfer over time”, which Kaplinsky and Morris associate with ‘high trust chains’ (Kaplinsky and Morris 2001, p.74), in which “failure to reach the required level of standards does not automatically result in the sanction of exclusion; instead executive governance is exercised to assist the transgressing party to achieve the required levels of performance” (ibid. p.31-32).

Such support may be an indicator of high levels of trust within aligned chains, with underperformance resulting not in immediate exclusion, but in “executive governance [being] exercised to assist the transgressing party to achieve the required levels of performance” (Kaplinsky and Morris 2001 p.31-32).¹⁸⁰ Such support could equally be regarded as a mechanism through which supermarkets achieved closure around technological frames. Put differently, supermarkets develop their meanings of problems and solutions of dairy farming through data gathering and benchmarking, and then feed this back to farms through extension. In benchmarked pools, therefore, farmers participate in this process of frame stabilisation and closure *only to the extent that* they are able to outperform other farmers in the pool (i.e. opportunities to influence buyers’ demands – see 7.3.3.2 – are restricted to the top-performing farms).

‘Methods of price determination’ serve as an additional metric for assessing trust relations within value chains, with low trust chains being characterised by price determination that is “adversarial, with hiding of information” and high trust chains being characterised by price determination that is “non-adversarial with ‘open books’” (Kaplinsky and Morris 2001 p.74).

¹⁸⁰ As an aside, the provision of extension and support by supermarket buyers was not limited to failing farms, as **Farmer D** reported: “... [Sainsbury’s] are putting out some really good stuff, they’re doing business improvement groups so that farmers can go and learn bits and pieces ... they do these business clubs which are really good where they get groups of farmers together for a couple of days, to talk about the business issues, and they’re quite inspiring ... [They’re] keeping us very up-to-date on the marketplace as well, in terms of feed prices, which helps us decide whether we should buy forward for feed, or hold back, that sort of stuff ... it helps to change the mindset.”

Farmer E gave an indication of the transparency of the cost of production data being collected by Sainsbury's:

"All the data is anonymous ... Sainsbury's isn't allowed access to any of it individually ... it's used through an intermediary ... They gather all the data, collate it, and put it into a readable form, so you get your own personal data. Then we're split into [geographical] zones ... so you can then compare your data to that zone, all anonymously. You can also then compare your data to the full Sainsbury's hub, or other zones individually. And ... Sainsbury's are now working a lot with Kite [Consulting], so we can now compare our data to Kite non-aligned [farmers] as well."

Although the anonymity of individual farmers was maintained within this arrangement, the supermarket nevertheless enjoys full disclosure of its suppliers' *collective* production costs. Arguably, price determination within aligned value chains should not be viewed as the product of an interaction between a supermarket and an individual farmer (indeed, all of Sainsbury's farmers receive the same base price). Instead, where prices within aligned value chains were determined on a cost of production basis, this should perhaps be viewed as the product of an interaction between a supermarket and a supplier pool as a whole, for which complete transparency of production costs has been provided. In the case of cost of production contracts within aligned value chains, therefore, it is arguable that not only are prices determined according to an ever-tightening standard but, moreover, the books are only open on one side of the negotiating table. This represented a significant information asymmetry between supermarkets and farmers, which many aligned farmers appeared oblivious to (or unconcerned by).

Whereas the threat of exclusion for poor performance was increasingly visible within the Tesco producer group, Sainsbury's approach to cost of production data collection and benchmarking was described by **Farmer E** as being more 'carrot' than 'stick':

"[We've] never felt the extreme pressure putting in this data ... it's all been gently pushed along and, you know, [the message has been] 'this is going to work', and you can see the benefit ... before you have a chance to think 'we are being controlled'."

However, the farmer expected this to change in future:

"I suspect [penalties] will start to come in. It's been a very hard year for the supermarkets; they've spent millions keeping us going ... [and] if you can't keep up then you're going to start becoming a problem... Because we're all doing well, so the pool is producing more milk and Sainsbury's is now buying more than it sells ... and that's not right. I don't massively follow the Tesco [pool], but they monitor their farms, they invite better farms to come in, and they drop the bottom percent ... So you do wonder, therefore, whether this might be something that other supermarkets would also think about, because ... they need to get our costs down..."

In the case of **Farm E**, these increasing pressures and expectations were manifested in tensions between the buyer's demands and the farmer's attachment to the Shorthorn cattle farmed by previous generations on the farm (see 9.2, above):

"[Keeping Shorthorns] has become a bit of a problem. Because they yield less, and because we are an aligned supplier we get rewarded for milk so we obviously want to maximise that ... currently we've got 90 Shorthorns and 90 black and whites ... and I need to reduce those Shorthorns to 45. And that is being ... influenced by our aligned supply to push it down... and it's probably not so much that the supermarket is encouraging us to produce more and more and more, but they are very closely monitoring our costs of production and we are paid on cost of production and they want to get that down... certain things, like the Shorthorns, a lot of our facilitation to change it has come from this benchmarking meeting..."

Farmer D suggested that, although Sainsbury's did not yet appear to be operating a policy of terminating the contracts of its worst-performing farmers (i.e. the threat of exclusion was less present), nevertheless, basing the milk price on the average cost of production of the supplier pool created a natural incentive for farmers to reduce their production costs:

"The nature of the game on aligned contracts is to be in the top 25%, because if you're gonna make any money at it you need to be better than the average, don't you?"

Having said that, the farmer was uncertain as to whether such pressures were exclusive to aligned suppliers:

"I don't know if that's what drives farms to make improvements or not. I mean, you're always driving efficiencies into your business because that's the nature of business... it's what you're going to do, or at least trying to."

Nevertheless, even if farmers were 'going to do' these things, regardless of buyer pressure, it did appear that such pressures encouraged farms to take action *sooner* than they might otherwise. Put differently, if buyer demands didn't influence the *direction* of change, they at least influenced the *rate* of change. **Farmer B**, who had previously been a Tesco supplier (via Arla) but had made the decision to forgo his Tesco Direct contract in favour of Arla co-operative membership (see also above 8.4.2), made a similar observation regarding the difficulty of disaggregating the influence of buyers' demands for efficiency improvements from broader, sector-level influences:

*"[The aligned contract] made you a bit more aware of the inputs and outputs and made it a bit more focused ... we just tried to make the system better and just improve on it really, which probably would've come with the other [non-aligned contract] as well ... but I think it's just **probably a bit sooner on Tesco**. [It made us] a bit more focused on ... efficiency ... Probably the cow health is ... the primary benefit first and then all the rest is just a chain reaction..." (emphasis added)*

However, the farmer's suggestion that his efforts to make such improvements came "a bit sooner" as a result of the Tesco contract suggests that aligned producer pools serve to *accelerate the rate of change* along established trajectories. Again, the fact that supermarkets operated 'waiting lists' (see above, 9.3.1.1) provides further evidence that aligned pools resulted in expectation and co-ordination effects across the sector.

Putting sector-level co-ordination effects to one side, farmers were divided regarding the effect of benchmarking *within* aligned pools, chiefly as to whether the practice influenced all aligned producers to converge upon the same model of production, through co-ordination and/or expectation effects *within* the pool. For **Farmer C**, benchmarking created significant pressure to intensify his system, which was in conflict with both the farmer's beliefs about the 'right' way to farm ("I like to see cows at grass") and about his preferred lifestyle and its relationship with the farm's physical environment (discussed above 9.2):

"I benchmark myself against these guys on the high output systems, and it makes me question whether our system is going to be viable ... I sit on this [Tesco farmers] board and certainly three of the farmers I sit with there are pretty intensive housed units and ... I don't really want to do it, but I'm worried that how we do it is being threatened ..."

However, **Farmer C** maintained that Tesco was not explicitly advocating one system or another:

"I'm sure there will be some research on which system is the cheapest ... [but] ... I think Tesco's mantle is, if it's done to prescription, and it's done well, and the animals are well cared for, we're not going to tell how to farm. The models they're looking at at the moment for benchmarking it's not so much about benchmarking systems against systems, it's about benchmarking people within a system..."

Farmer E explained the influence of her involvement with discussion groups run by Sainsbury's, and had been invited to participate in "a much more rigid benchmarking group", called 'BIG'. She emphasised the *variety* of farms involved in the benchmarking group:

"We meet as about 20 farmers, one representative from each farm, and we're not defined by area or size or anything else... we meet as completely different people, [from] right the way up to the border of Scotland down to Cornwall... some would be [using] robots, some would be big farms, some would be block calving... there's no defined structure as to who you are. So we meet on somebody's farm and you do serious benchmarking, you declare all your costs, you discuss, you're critically analysed, and then they also update you on the market and things."

The analysis shows that supermarkets that benchmarked farmers framed the problems and solutions of dairy farming in terms of production costs and compliance with environmental and welfare standards (e.g. Tesco's 'balanced scorecard' approach assessed farms' performance in terms of 'quality', 'value', 'innovation' and 'service'; see 7.3.3.1). Although this appeared to

permit a variety of different farming systems to operate within aligned pools, in practice the competition between farms engendered by benchmarking and cost-of-production pricing (and the creation of expectation and co-ordination effects that this created) resulted in a narrowing of frames around the models of those farms with the lowest production costs. Therefore, while farms with low production costs participated with supermarkets in a process of collective frame stabilisation and closure, the participation of other farms was marginalised.

9.3.3.2 Animal Welfare and Environmental Performance

Aligned farmers in particular emphasised that supermarkets placed a clear emphasis on animal welfare and environmental performance (see 7.3.3.2). According to **Farmer E**:

“As soon as we went with Sainsbury’s they started introducing targets for us to hit ... the first thing that was brought in was mobility scoring ... lameness in the herd was suddenly looked at in a very different way and you suddenly realised that once you could measure something you could control it a bit more ... And then we started measuring other things and before you know it the performance of the herd becomes extremely important.”

Performance against these metrics was viewed by supermarkets within the context of controlling broader production costs (9.3.3.1). According to **Farmer D**:

“Lameness and mobility is a big thing, mastitis levels are a big thing. Overall KPIs, like your calving index, cost of production they are very interested in, because that’s what they’re basing their price on, so they want us to reduce our costs as much as we can

The influence of supermarkets’ focus on these metrics was felt outside of aligned pools. Non-aligned **Farmer N**, who was hopeful of securing an aligned contract, explained that would be willing and able to jump through *“Whatever hoops we were given to do”*.

9.4 When Buyer Power Fails to Influence Technological Change

This section considers examples of failures of buyer power to influence technological change where these illuminate the examples of successful influence discussed in section 9.3.

9.4.1 Security of Supply: A/B pricing

Sainsbury’s supplier **Farmer E** explained that the supermarket had begun to impose limits on volume, based on their previous production levels:

“They are effectively going to quota us, so we’ll only be paid for a certain amount, and then any milk over that will continue to go through Muller ... When originally I heard that, it put me off growth ... because it’s basically [an] A and B price, and it [the B litres] will dilute my A price ... but actually when you look at it a little bit more ... and perhaps I got to grips with it a little bit more by speaking to other Sainsbury’s suppliers... they were saying ‘well, you’re still

getting a good price... you're getting a better price than anyone else, so why not push more and produce a bit more?'"

This supported the view, proposed in **Chapter 7**, that the sanctioning effect of supermarket-imposed volume limits may be relatively less punitive than the sanctioning effect of A/B pricing within non-aligned contracts (7.3.1.3), because the 'B' price under an aligned contract is typically the processor's standard liquid price rather than the spot market price.

9.4.2 Production characteristics

Farm B, who had switched from a Tesco Direct aligned contract to an Arla co-operative membership, suggested that benchmarking was "unfair" insofar as it compared a diverse range of systems against the same (cost of production) standard, regardless of the fact that some of these systems were constrained by their available physical resources:

"I think the unfairness of the comparison is probably where the land is. Because if you're on flat ground with reasonable rainfall, rather than heavy rainfall over the year, you can also graze your cows more which then would keep your cost of production lower. We're probably in the halfway middle of it and the more expensive system is probably keeping the cows indoors all year round... but the way they benefit is more litres, so they are producing a lot more litres at a smaller margin.

Further, he queried the effect that this would have on the overall size of the pool (see further **Observation 2, Chapter 10**) and, consequently, the ability of farmers to compete within it:

"The thing with Tesco, they have brought out a new thing now, that you have to be in the top 95% of farmers... But, slowly the one [reason] where I'm more pleased to be on an Arla contract is [because if] every year they take 5% off... It's always going to get smaller and smaller... from being a big number of farmers, if you're average now, in ten years time you might be at the bottom."

Chapter 10: Discussion

This chapter evaluates the findings detailed in **Chapters 7 to 9** in order to answer the research question:

In which ways, and through what mechanisms, does buyer power influence the reproduction of farm-level socio-technical systems for the agricultural production of liquid milk in the UK?

There are two elements to this research question. The first concerns the ‘ways’ in which buyer power influences the reproduction of farm-level socio-technical systems, which in the context of this thesis involves a consideration of both the speed (i.e. rate of change *within* clusters) and the direction (i.e. movement *between* clusters) of change. It is notable that most farms examined in the study exhibited change *within* a single cluster over the full duration of the study, although some appeared to be moving *between* clusters (*tendencies* towards movement between clusters could often be observed, rather than actual between-cluster movement). The second element of the research question concerns the mechanisms through which such influence is achieved. The relationship between the two elements of the research question should be clear from the analysis in **Chapters 7 to 9**. Due to this relationship it is neither possible, nor desirable, to treat the two elements completely separately within this discussion.

The following sections are partitioned into: 1) distinctions observed between different value chains; and 2) distinctions observed between different farm systems. These findings are interwoven with an assessment of:

- The extent to which these knowledge claims are original,
- The degree to which these claims narrowly address the research question or have more general application (i.e. in answering similar questions in other contexts, and therefore contribute to more general ‘ways of understanding’)
- The degree to which these claims are ‘speculative’ or not (and the extent to which they, therefore, imply areas for further research).

10.1 Distinctions Between Value Chains

While the direction of socio-technical system reproduction *as a whole* was towards greater intensification of production across the research period (farms that were ‘intensive’ at the outset intensified [e.g. **Farms F, I, M, O; 7.1**], some extensive farms extensified [**Farm P, 8.1**], while intermediate farms more frequently tended towards intensification than towards

extensification; e.g. **Farms E and C, 9.1**), the analysis clearly demonstrated that this pattern was not due to incremental technological improvements alone. Instead, buyer demands had influenced both the *rate* and the *direction* of change, where such demands were supported by strong sanctions and high levels of trust. In particular, these characteristics were more typical of aligned than non-aligned value chains (7.3, 8.3, 9.3).

Buyer influence was therefore most readily observable within aligned chains. However, it was also apparent that farmers within aligned value chains were more likely to influence – as well as to be influenced by – buyer demands. Moreover, and significantly, the influence of supermarket demands was also felt within non-aligned value chains (e.g. **Farm O, 7.3.3.1, Farm N, 9.3.1.1**, albeit such influence was not uniform across aligned and non-aligned chains).

Specifically, the following observations can be distinguished between farms within different value chains, regardless of system type:

OBSERVATION 1: Aligned value chains were characterised by stronger sanctions (in the form of high, stable base prices and the power to exclude) and higher levels of trust between value chain participants, when compared with non-aligned value chains. As a result of these conditions, farmers supplying supermarkets were more likely to be influenced by buyers' demands than non-aligned farmers and, moreover, supermarkets were able to influence non-aligned farmers.

Supermarkets' ability to influence farmers therefore depended upon the presence of non-aligned value chains containing weaker sanctions and lower levels of trust, and buyers' ability to influence farmers was not only a product of their greater power relative to farmers but also of the degree of price variation and the diversity of contractual arrangements available in the market (see 7.3.1.1, 8.3.1.1, 9.3.1.2).

This finding provides a meaningful contribution to our understanding of the “divided market between the ‘haves’ supplying liquid milk to the supermarkets and the ‘have-nots’ that supply processed products into commodity markets” (House of Commons 2011, p.14). It presents strong evidence not only of the “equity divide” between aligned and non-aligned value chains (i.e. that farmers within each value chain receive widely varying prices for a broadly similar product; Dewick and Foster 2007, p.33), but also that this system of ‘haves’ and ‘have-nots’ influences producers’ technological approaches *across the sector*. In particular, non-aligned farmers sought to emulate the approaches taken by aligned farmers, in the hope of securing an aligned contract (**Farm O, 7.3.3.1, Farm N, 9.3.1.1**). Taken alongside the findings discussed below (**Observations 2 to 4**), this serves to drive homogenisation at the sector level.

Similarly, the analysis demonstrates that the strength of sanctions was not only a function of a buyer's power relative to farmers, but was also a result of their power relative to other market participants, including other buyers. For example, the extent of a buyer's 'power to exclude' depended upon the availability of alternative buyers (i.e. the physical location of farms) as well as the prices paid by those other buyers. The power to exclude was greater within aligned value chains due not only to the higher, more stable prices paid by supermarkets (e.g. see **Section 7.3.3.1, Farmer O**), and the relative scarcity of supermarket contracts¹⁸¹ compared with non-aligned contracts, but was also a result of supermarkets' greater market power relative to other buyers. This greater market power was expressed, in particular, through supermarkets' practice of re-tendering processing contracts for aligned pools (in the words of **Farmer E**, "they have played the processors off against one another"; **9.3.1.1**). This situation resulted in farmers relinquishing control over who processed their milk.

This study focused upon relationships between buyers and farmers, meaning that relations between other participants in the value chain were largely outside of its scope. However, this finding strongly suggests that a deeper analysis of interactions and power dynamics between supermarkets and processors (who serve as 'contract processors' – or intermediaries between supermarkets and farmers – within aligned chains) and between large and small processors¹⁸², and in particular of conditions of trust within the wider value chain, may provide fruitful avenues for further research, given that processors operate across both types of value chain (see **10.3**). Notably, such research may further illuminate the ways in which the power of processors varies between aligned and non-aligned value chains, and may reveal impacts of this upon farmers, such as, for example, the potential for processors to pass costs associated with aligned contracts on to their non-aligned suppliers.

At a more general level, the finding that farmers were influenced by buyer demands broadly supports Hayami and Ruttan's extension to the induced innovation hypothesis, namely their view that technological change in agriculture results from variations in *both* the "conditions of factor supply" and "product demand" (Hayami and Ruttan 1985, p.73; see **Chapter 3**).¹⁸³ However, the induced innovation model predicts that firms innovate in response to price

¹⁸¹ "Because of the structure of the milk supply sector, only about 3% of milk producers are direct suppliers to retailers" (House of Commons 2015, p.15)

¹⁸² e.g. Within non-aligned value chains, consolidation in the processor market, in combination with the practice of discretionary pricing, meant that powerful processors were able to both influence milk prices at the sector level, and to attract and retain farmers who were concerned about the relative insecurity of smaller processors' contracts (see, e.g. **9.3.1.2**).

¹⁸³ Albeit the influence of such prices was "*within the boundaries* defined by the nature of technological paradigms" (Dosi 1988, p.226-7; see further below, **10.3**).

changes, notably increased input costs or reduced product prices. Whereas induced innovation theory therefore implies that high product prices reduce firms' incentive to innovate, the findings indicated that aligned farmers – receiving the highest, most stable prices – innovated as much as, if not more than, non-aligned farms, which, due to expectation and co-ordination effects, often followed the example of aligned farms.

Moreover, although Hayami and Ruttan argued that “a fully developed general equilibrium theory of induced innovation ... should incorporate the mechanisms by which changes in both product demand and factor endowments interact with each other” (ibid. p.85), the findings strongly suggest that any consideration of these interactions should involve a more comprehensive account of:

- (a) The significant heterogeneity within both “conditions of factor supply” (i.e. ‘resources’) and “product demand” (i.e. not only demand for increases or decreases in volume, expressed through milk prices – which exhibit considerable diversity and volatility¹⁸⁴ – but also other buyer demands, such as those relating to product or production standards) across the sector¹⁸⁵; and
- (b) The observation that – as a result of this apparent lack of uniformity in product demand, manifested in high levels of price variation – market-leading prices exert both a direct influence (on farms currently receiving such prices) and an indirect influence (on farms that aspire to receive such prices in the future). Moreover, future research might examine whether the extent of such influences is related to the degree of price variation within markets (i.e. whether the influence of buyers offering higher prices increases as the difference between the highest and lowest prices available increases).

When developing their theory, Hayami and Ruttan considered “increases in population or per capita income resulting in increased demand for food” (ibid. p.85) as an example of “product demand”, and appeared to assume that this pattern acts uniformly across the agricultural sector at any given time. Such an assumption overlooks the differences in patterns of demand that this study clearly identified occurring at the subsector level, related to different buyers' ‘balancing strategies’, end markets and so forth (see **Chapter 5**).

¹⁸⁴ NB: Hayami and Ruttan focus on long term “secular” trends, such as the changes in production and demand witnessed within the agricultural revolution in England between the 15th and 19th centuries (Hayami and Ruttan 1985. p.97), rather than the influence of shorter term price / demand volatility upon technological selection.

¹⁸⁵ With variations in the latter potentially resulting from downstream factors (e.g. differences buyers' ultimate end-markets; consumers in the case of supermarkets and retailers, food services, global commodity markets etc in the case of processors), see areas for further research (**Observation 2**).

Further, Hayami and Ruttan "... hypothesize[d] that technical change is guided along an efficient path by price signals in the market, provided that the prices efficiently reflect changes in the demand and supply of products and factors..." (ibid. p.88). This study demonstrates that the assumption that "... prices efficiently reflect changes in demand..." is problematic. Within the dairy sector, the prices received by farmers on non-aligned contracts, supplying milk destined for liquid markets, may be influenced by changes in demand within other markets (e.g. markets for commodities such as skimmed milk powder [SMP], butter and cream etc) and therefore may be influenced as much by the processor's exposure to such markets as by fluctuations in demand for *liquid* milk (see **Chapter 5**).

Moreover, within aligned value chains that operate a cost of production pricing model, milk prices are effectively 'decoupled' from demand, i.e. prices will reduce based upon reductions in the average production costs of producers within the pool, rather than solely as a reflection of reduced demand. Where such buyers engage in the practice of benchmarking farmers on the basis of production costs, eliminating the worst-performing farms in the process (see **7.3.3.1**), prices will exhibit, over the longer term, a steady downward trend, regardless of levels of product demand.

Both the processors' capacity for discretionary pricing, and the supermarkets' ability to 'decouple' price from short-run changes in levels of demand, are indicators of the unequal distribution of power between farmers and buyers that exists within the value chain for liquid milk (i.e. farmers are 'price takers' and buyers 'price setters'), which this study demonstrates has a significant impact upon farms' selected production approaches, and which may be overlooked by an induced innovation perspective, which assumes that 'prices efficiently reflect changes in demand'.

In summary, the findings of this study call into question the suitability of applying a sector-level analysis to understanding technological change within a sector such as dairy farming, in which there is a considerable variation in the power of actors and market prices, and in which 'product demand' may vary along a range of dimensions (price, volume, seasonality, product quality, etc). Instead, a farm-level approach – as adopted within this study – can more effectively capture and explain the different approaches taken by different farms.

OBSERVATION 2: *The high, stable base prices paid by supermarkets resulted in investment effects at the farm level, which stabilised the direction of farm reproduction and/ or accelerated the rate of change. Because high, stable prices enabled farm expansion, aligned producer pools tended towards consolidation and overproduction over the longer term in the absence of effective limits on production.*

Supermarkets clearly paid the highest, most stable milk prices, which encouraged aligned farms to increase milk production and allowed them to plan, invest and expand, resulting in investment effects at the farm level (see 7.3.1.1, 8.3.1.1, 9.3.1.2). This increased the rate of aligned farms' progress towards established goals and/ or inhibited future changes of direction in socio-technical systems at the farm level (e.g. **Farm F, Chapter 7; Farm E, Chapter 9**).

Further, the sanctioning effect of supermarket-imposed volume limits was less punitive (and less effective) than the sanctioning effect of A/B pricing within non-aligned value chains, due to the degree of price variation within the market, as a result of which, supermarkets' 'B' prices remained high relative to broader market prices (see 7.3.1.3; 9.3.1.3).¹⁸⁶ This, in combination with the investment effects described above, implies that aligned pools – *ceteris paribus* – tend towards overproduction over the long term, relative to supermarkets' levels of demand.

This finding calls into question the long-term sustainability of aligned pools (as currently constituted) and supermarkets may be expected to introduce changes in response to this. Tesco's practice of terminating the contracts of its least efficient farmers (albeit while awarding additional volume allowances to the most efficient farmers) might be viewed as one method of mitigating the risk of overproduction, although it may also contribute towards (or accelerate) a trend towards consolidation within the pool (i.e. result in fewer, larger farms over the longer term).

Within smaller aligned value chains (i.e. Waitrose and Marks & Spencer) consolidation resulting from the effects of high, stable pricing was already in evidence, with expansion in individual farm sizes accompanying a reduction in farm numbers over time (see **Chapter 10**). Likewise, the Sainsbury's producer pool had also reduced in producer numbers over the study period (attributed to "natural shedding", i.e. retirements), at the same time as overall milk volumes had increased (**Farmer E** claimed that "Sainsbury's is now buying more than it sells"), indicating a similar tendency towards consolidation, farm expansion, and overproduction (see **Chapter 9**).

¹⁸⁶ Although if price variation in the market were to reduce, for example due to reductions in aligned prices because cost of production pricing results, over the longer term, in a steady reduction in prices over time (see above), then one might assume that supermarket A/B pricing might become a more effective means of controlling volumes

Although the Tesco pool provided an exception to this pattern (expanding from 600 to 750 farmers during the study period¹⁸⁷) this can be attributed to a policy change implemented by Tesco after a review of its producer pool in 2015, following which the supermarket resolved to source all of its milk from *within* the pool (whereas it had previously procured milk from outside of the pool in order to meet temporary seasonal shortfalls¹⁸⁸). **Farmer O**, who had operated as one of these 'seasonal' farmers prior to being awarded a 'full' Tesco contract, explained: "When we were on the seasonal [contract] we weren't audited by Tesco... they just used our milk ... now what they want is that *all* their milk comes from full Tesco farms. So ... now ... they've got enough farms that will *match their highest [level of] demand*".

Tesco's desire for increased control over – and transparency regarding the sourcing of produce within – its value chain is most likely related to a perceived consumer demand for improved product traceability, following the 2013 'horsemeat scandal'¹⁸⁹, which prompted a pledge from the supermarket to "work harder than ever with all our suppliers"¹⁹⁰. The influence of end consumers within value chains for liquid milk is therefore a significant area for further research (see further, below). Although this policy change meant, in the short term, an expansion in producer numbers, one would expect that the accompanying policy of excluding the worst performers will, over the longer term, *reduce* overall producer numbers. Indeed, there was clear evidence that individual Tesco producers had expanded output as a result of high, stable milk prices (e.g. **Farm F**, 7.3.1.1; **Farm C**, 9.3.1.2) and it was also clear that intermediate farmers in particular were feeling pressure to emulate the larger, higher output intensive farms within the pool (e.g. **Farm C**, 9.3.3.1; see also **Observation 4**). The tendency towards consolidation and overproduction within the Tesco pool was therefore also clearly evident.

Finally, the fact that Tesco is aiming to source all of its milk from within its supplier pool, suggests that there will be heightened pressure on Tesco farmers to produce level year round production in the future, to ensure that Tesco avoids over- and under-supply. This implies a homogenisation within the Tesco producer pool as farmers switch to all year calving (which may serve as a 'gateway' to further intensification involving, as it does, longer periods of housing and lower levels of grazing compared with Spring calving systems, for example).

¹⁸⁷ <https://www.thegrocer.co.uk/buying-and-supplying/categories/dairy/tesco-wants-to-add-150-more-farmers-to-sustainable-dairy-group/525320.article>

¹⁸⁸ Personal communications with NFU (10/2/14) and DairyCo (2/12/14) representatives suggested that, historically, it had been common practice for supermarkets to recruit farms on a temporary basis in order to 'balance' shortfalls in production

¹⁸⁹ https://www.fsai.ie/uploadedFiles/Enforcement_and_Audit/Horse_Meat/Equine-DNA-DAFM-March-2013.pdf

¹⁹⁰ <https://www.tescopl.com/news/news-releases/2013/an-apology-from-tesco/>

A related effect of high, stable supermarket base prices – and the superiority of these relative to other prices available in the market – was that they compounded farmers’ reliance on supermarkets, through enhancing the supermarkets’ power to exclude (5.2.6; 7.3.3.1; 9.3.1.1). The influence of this upon the reproduction of socio-technical systems was that farmers in aligned pools would readily ‘jump through hoops’ (i.e. comply with buyer demands) for fear of losing their contracts and, moreover, farmers appeared reluctant to pursue alternative paths of development that might conflict with their current contracts (both of these contributing to a tendency towards homogenisation in these pools, outlined further below; **Observation 4**). Notably, **Farmer E** was discouraged from diversifying her business into the direct marketing of milk within local markets, for fear that such a move would conflict with her current contractual arrangements with Sainsbury’s. As well as stabilising the farm socio-technical system, this therefore served to further *compound* the farmer’s reliance upon Sainsbury’s, restricting her to supplying a single, large, buyer as opposed to negotiating with several buyers.

At a high level, this finding serves to support, and offer further insight into, the interrelationship between the different dimensions of value chain governance expounded by Kaplinsky and Morris; in this case, ‘sanctions’ (expressed through milk prices and the power to exclude) and ‘trust’ (indicated by ‘reliance’). However, this finding also offers a contribution towards a more fine-grained understanding of the diversity – and dynamics – of reliance within different value chains for liquid milk, and highlights areas for further research.

‘Reliance’ is widely interpreted as an indicator of trust within a value chain (see 3.6.3, and 5.2.6). Broadly, where buyers rely upon a small number of suppliers to meet their needs, and suppliers rely upon a small number of buyers, this indicates ‘high’ levels of trust. Where the opposite conditions apply, trust is regarded as being ‘low’ (Kaplinsky and Morris 2001, p.74). However, a strong asymmetry was apparent in conditions of reliance within value chains for liquid milk. Dairy farmers, as a rule, are heavily reliant upon buyers, generally having a single buyer for their milk; this was true of all of the farms within the study. By contrast, buyers are typically supplied by dozens, if not hundreds, of farmers and their reliance upon individual farmers is correspondingly low. Further, one implication of these considerations regarding consolidation within aligned pools is that conditions of reliance (and, therefore, ‘trust’) differ between large aligned, small aligned, and non-aligned value chains, and the issue of reliance on *both sides of the buyer-supplier relationship* merits closer examination, presenting an avenue for further research.

The findings of this study imply that farmers’ reliance upon current buyers is a function not only of the number of buyers that the farmer currently supplies (i.e. typically, ‘one’) and the

proportion of the farm's milk that each of these buyers receives (i.e. typically '100%'), but that a more nuanced understanding of reliance can be obtained by considering the availability of alternative buyers, the prices paid by those buyers, and their wider contractual terms (see, e.g., **Farmer I**, 7.4.3; **Farmer N**, 9.3.1.1). The study found numerous examples of the influence of variations in milk prices and contractual terms upon farmer decision-making, and, broadly, farmers in non-aligned chains (characterised by low, discretionary milk prices) were much more willing, and able, to switch buyer (within the limits of geographical location) (cf. **Farm M**, 7.4 and **Farm K**, 8.3).

On the other side of the equation, *buyers' reliance on farmers* will vary depending upon the proportion of the buyer's total milk requirements that a particular farm supplies, and the buyer's ability to cover any shortfall resulting from that farmer exiting the pool. This shortfall may be covered either by the remaining farms within the pool (depending on the number of farms remaining and their individual capacities for expansion); by recruiting new farms from outside the pool (depending on the availability of alternative farms with a proven record of supplying milk in the volumes and to the specifications required); or by purchasing milk from the spot market (which may be the cheapest and/or most straightforward option).

On the face of it, consolidation within aligned pools suggests that – *ceteris paribus* – (particularly smaller) supermarkets' reliance on farmers is greater than (particularly larger) processors' reliance on farmers (as pools consolidate into fewer, larger farms, those farms represent a larger proportion of the buyer's overall milk needs). Looking closer, the findings suggest that there may be further distinctions between aligned and non-aligned value chains, related to buyers' 'balancing' strategies (i.e. how they manage underproduction and oversupply). Broadly, processors might be expected to have greater flexibility with regards to managing shortfalls and surpluses than supermarkets (and therefore have lower reliance on individual farmers), for the following reasons:

- Pledges for increased transparency within aligned value chains (exemplified by Tesco's change of policy to require that "*all* their milk comes from full Tesco farms") appear to have brought the challenge of recruiting replacement farmers into sharper focus for supermarkets, which may be less readily able than processors to simply purchase milk from the spot market in order to cover shortfalls. Having said that, the broader homogenisation within the sector (e.g. due to expectation and co-ordination effects originating from aligned value chains, discussed more fully below; **Observation 4**) tends to diminish the scale of this challenge (i.e. as the production sector becomes increasingly homogenous, it becomes easier to replace exiting farms).

- The large processors, in particular, own¹⁹¹ (rather than lease) processing facilities, permitting them greater flexibility and control regarding the management of surpluses, compared with smaller processors or supermarkets (which lease processing facilities or subcontract the processing function, and which therefore have greater economic and/or logistical barriers to the *ad hoc* use of such facilities).
- Whereas the supermarket aligned pools considered within the study were restricted to liquid milk for drinking, processors often supplied a broader range of end markets¹⁹² (SMP, whey powder, etc), therefore enjoying more direct access to those markets for the disposal of surpluses.

A full exploration of the above dynamics was beyond the scope of this study, which did not gather or analyse sufficient data fully to assess buyers' reliance on individual farmers. Similarly, the study did not consider in depth the effects (if any) that supermarkets' investments in aligned pools (i.e. investment effects associated with research and extension, see **Observation 3**) had upon supermarkets' reliance on farmers.

However, the findings do provide considerable preliminary evidence to suggest that *smaller* supermarkets are more reliant upon individual farmers compared with other milk buyers, warranting further research. Such reliance was demonstrated, for example, by the clear willingness of Waitrose – which is supplied by approximately 50 farms¹⁹³ – to co-operate, collaborate and negotiate with its farmers, over long time periods. Notably, **Farmer K** described his nine-year process of negotiation with Waitrose, regarding the supermarket's demand for level year round production, which culminated in the supermarket conceding and inviting the farmer to take part in a trial for seasonal production (**8.3.1.1**).

Further, while the purpose of this discussion is not to suggest that there is parity between buyers' reliance on farmers and farmers' reliance on buyers, nevertheless, it does imply that subtle shifts in the power dynamics between supermarket buyers and farmers may accrue as aligned pools mature. It also identifies a clear categorical distinction between farmer-supermarket and farmer-processor relationships. One potential hypothesis for future testing is

¹⁹¹ For example, Arla owns the "world's largest fresh milk dairy"
<https://www.arlafoods.co.uk/overview/news--press/2014/pressrelease/world-s-largest-fresh-milk-dairy-is-officially-opened-by-secretary-of-state-1001612/>

¹⁹² See **Figure 5a**. Also see DairyCo 2013b, p.14

¹⁹³
https://www.waitrose.com/home/inspiration/about_waitrose/about_our_food/waitrose_dairy/dairy-farming.html; accessed 14/10/18

that consolidation within aligned producer pools increases buyer reliance upon farmers, which may reduce the threat of exclusion and increase the co-operation between buyers and suppliers.

One might also hypothesise that it would be against buyers' interests to promote excessive consolidation (and the expansion of individual producers¹⁹⁴) within supplier pools, as ultimately this trend may increase buyers' reliance upon farmers, resulting in greater parity in bargaining power between producers and buyers. This points, therefore, to an inherent tension within the aligned-segregated pool model, which may ultimately be unsustainable from the supermarket's perspective as it tends towards an ever-smaller number of increasingly-large producers. Supermarkets appeared to be alert to these trends and risks.

Finally, the sustainability of these pools is further called into question by evidence of the financial cost to supermarkets of operating them. In 2016, Tesco claimed that it had paid £240m over market prices to farmers in its supplier pool, in the nine years that it had been operating its Tesco Sustainable Dairy Group (TSDG).¹⁹⁵ Within an increasingly competitive retail environment, the continued viability of large aligned pools (as currently constituted) may depend upon the value they present to supermarkets in terms of 'public relations' (PR; see, e.g. **Farmer N**; 9.3.1.2). The fact that supermarkets had begun to exclude the least efficient farms from their supplier pools suggests that changes to the aligned / cost of production model were well underway, and that the cost of operating aligned pools was beginning to exceed their 'PR' value. As **Farmer E** suggested, Sainsbury's had "... spent millions keeping us going, so I'm sure now it's going to get to a point where there will be penalties".

As suggested above, this discussion highlights an important area for further research, namely, the need to develop a more complete picture of downstream influences (i.e. from end consumers) upon supermarkets and, ultimately, on how these affect supermarkets' demands, farmers' decision making, and the longer-term sustainability of aligned, segregated pools. Indeed, Tesco's change to its 'balancing' policy (towards satisfying its "highest level" of demand from milk produced *within* the aligned pool) provided evidence of a clear connection between consumer demands for traceability, supermarkets' demands for level production, and farmers' production approaches. Consumer pressure for traceability creates risk for

¹⁹⁴ For example, a farm the size of the proposed 'Nocton Dairies' (see 2.3.2), with 8,100 high yielding cows, might be expected to produce 80 million litres of milk per annum, or 10 million *more* than the annual output of Marks & Spencer's entire milk pool, and 80% of the annual production of the entire Waitrose pool (DairyCo, 2012d, p.6)

¹⁹⁵ <https://www.dairyreporter.com/Article/2016/07/04/Tesco-unveils-Fair-For-Farmers-Guarantee-on-milk>

supermarkets as it limits their options for balancing. Supermarkets currently transfer this risk to their farmers through demands for level supply.

Although the analytical framework did not permit a close consideration of downstream (end consumer) influences on buyer demands, the findings did strongly suggest that downstream consumers and upstream producers might have influenced buyers' demands to differing degrees within aligned and non-aligned value chains. For example, the influence of end consumers appeared to be pronounced within aligned value chains, particularly around the issues of the 'fair' treatment of farmers (i.e. milk prices) and animal welfare (i.e. production standards; see **Farmer F**, 7.1, 7.2, 7.3.3.2; **Farmer E**, 9.3.3; **Farmer N**, 9.2). Moreover, in some cases supermarkets' demands appeared to be potentially inconsistent with each other, ostensibly as a result of their attempts to satisfy a diversity of conflicting end consumer requirements. For example, Waitrose was demanding a level production profile from its farmers, while simultaneously demanding a minimum period of annual grazing (100 days; see **Chapter 8**).

A deeper consideration of the influence of end-consumer demands might therefore enrich our understanding of the process by which 'frames' are stabilised within value chains for liquid milk (see below, **Observation 3**).

Moreover, a focus upon the role of end consumers highlights the necessity for further research into the potentially contradictory effects of aligned pools upon the ability of producers to capture returns. Broadly, producers of commodities capture a small share of the value from the sale of products due to "the relatively undifferentiated nature of final product markets" (Kaplinsky and Fitter 2004 p.7). On the one hand, consumer influence within the UK milk market may contribute towards a 'de-commodification' (Kaplinsky and Fitter 2004) of liquid milk (in the limited sense that the development of aligned supermarket pools – ostensibly in response to consumer demands for improved traceability, animal welfare standards, or the 'fair' treatment of farmers – may be regarded as introducing greater product differentiation into the liquid milk market). On the other hand, the homogenisation of production (see **Observation 4**) associated with aligned pools tends to militate against this, resulting in a less-differentiated production sector.

OBSERVATION 3: *The higher levels of trust within aligned value chains, compared with non-aligned value chains, resulted in (and from) the existence of longer, potentially more collaborative relationships between buyers and farmers. Such relationships provided some evidence of shared or mutually negotiated 'frames' that underpinned both buyers' demands and farmers' decision making. Farmers within aligned value chains were more likely to be influenced by buyers' demands, but also had some potential to influence those demands.*

The study showed clearly that the higher, more stable prices (i.e. positive sanctions) paid by supermarkets presented a powerful incentive for farmers to secure, and retain, aligned contracts, in particular given the degree of price variation in the market (**Observation 1**). Farmers' efforts to retain aligned contracts therefore resulted typically in longer relationships between farmers and supermarkets (e.g. **Farms E, F, C, K**). The analysis also suggested that these long relationships both resulted in (and from) stronger conditions of trust within aligned value chains. The tendency towards consolidation within these value chains over time suggested that participants' reliance upon each other would also increase over time (**Observation 2**). Further, the analysis revealed that non-aligned farmers were often willing to switch buyers with relatively higher frequency than aligned farmers (**Farm M, J**), and attributed this, by contrast, to weaker sanctions (low, volatile prices) and lower levels of trust.

A closer consideration of the findings also highlights not only distinctions between conditions of trust in aligned and non-aligned value chains, but also distinctions between the value chains of large and small supermarkets (see, e.g., **9.3.1.1**).

For the purposes of this study, 'trust' refers to participants' confidence in the continuity, reliability and predictability of the operation of the value chain (see **5.2.6**). Trust is enhanced (diminished) by conditions that support (threaten) such continuity, reliability or predictability. The study found evidence of higher trust conditions in aligned value chains, with farmers reporting that high, stable (i.e. predictable) prices had given them confidence in the continuity of the governance conditions in the chain, enabling them to invest in their businesses (**7.3.1.1, 8.3.1.1, 9.3.1.2**). By contrast, non-aligned **Farms I (7.4.3), M (7.4.1) and N (9.3.1.3)** complained of the volatile or low milk prices they received, and the obstacles this presented to investment in their businesses. It was, further, notable that *buyers* valued continuity (see **Farmers D and E; 9.3.1.2**).

The study also revealed evidence of the influence of such trust conditions upon (and their interaction with) farmers' 'mindsets', in particular with regard to their perspectives concerning the 'fairness' of the rules governing the operation of the value chain. Non-aligned farmers complained, for example, of the lack of transparency regarding the frequency with which, or methods by which, milk prices were calculated, whereas aligned farmers spoke of the 'fairness' of cost of production pricing.

It was therefore clear that the *process of price determination* enhanced conditions of trust within value chains for liquid milk. Within the value chains of larger supermarkets, cost of production pricing provided both confidence in the continuity or predictability of the milk price, as well as influencing farmers' mindsets regarding such price mechanisms (i.e. as the pricing was transparent and made by reference to a formula, as opposed to being discretionary, and it therefore protected farmers from wider market forces; see **Farmer C**, 9.3.1.2). This was in spite of the information asymmetries inherent in this method of price determination, and the fact that cost of production-based prices may inevitably decline over time through the exclusion of the worst-performing farms (see 9.3.3.1). Indeed, it is notable that, in spite of these tendencies, aligned farmers described the cost of production pricing mechanism as 'fair' (**Farmer F**, 7.3.3.1; **Farmer D**, 9.3.1.2).

Once again, it seems likely that these farmers' views were also influenced by the degree of price variation within the market, and by the fact that the prices paid under cost of production contracts were considerably higher than either spot market prices or non-aligned prices (indeed, all the aligned farmers expressed sympathy with farmers receiving prices that were below the cost of production). It is therefore conceivable that – if price variability was lower, and/or if aligned farmers were receiving the same, or less, than non-aligned farmers – their views regarding the 'fairness' of cost of production pricing might have differed. It should also be noted that the study did not include any farmers that were operating towards the 'bottom' of aligned pools in terms of efficiency (i.e. for whom exclusion from the pool therefore presented a more imminent threat, and who might have offered a different view regarding the 'fairness' of cost of production pricing), or farmers that had been excluded from such pools.

Within smaller aligned producer pools, trust derived to a greater degree from informal, interpersonal relationships between farmers and those individuals responsible for determining prices, which provided continuity, reliability and predictability by virtue of their long duration (see 8.3.1.1). Trust in these value chains could also be explained as resulting from buyers' increased reliance upon farmers due to consolidation in these pools (see above, **Observation 2**). The potential for farmers to influence buyers' demands appeared to be more pronounced within these value chains. Future research might test the hypothesis that there is a correlation between the diminishing size of producer pools and increasing levels of trust within them.

By contrast, non-aligned farmers' mindsets often revealed a different perspective on the 'fairness' of the milk value chain broadly, and of their own contractual arrangements specifically. In the case of **Farm N**, for example, the lack of communication or engagement

regarding changes to the composition of, or 'rules' governing, the value chain, exemplified the low conditions of trust within the value chain (e.g. **Farm N, 9.3.1.3**). More broadly, non-aligned farmers expressed 'frustration' with the low prices they received (**7.4.3**).

The finding that different levels of trust and sanctions existed between participants within aligned and non-aligned value chains (and the effects of these) provides an original contribution to the social construction of technology (SCOT) and path constitution literatures, as explained below.

The analytical framework used in this study compared system inputs and outputs (which served as a proxy for 'progress towards goals') against buyer demands (which served as a proxy for 'buyer goals'; see **Chapter 4**). Different degrees of 'correspondence' between farms' progress and buyer goals were observed, with correspondence tending to differ by system type (see further, **Observation 5**). These different degrees of correspondence provided a *description* of the *outcomes* of the inherently contested process of system reproduction. However, the different sanctions and different levels of trust observed within different value chains provided an *explanation* and *illumination* of the different conditions under which this contested process was conducted within aligned and non-aligned chains (i.e. sanctions and trust provided the mechanisms through which buyers "... strive for closure by convincing and committing relevant others to their perspective..."; Meyer and Schubert 2007 p.35).

Put differently, the different conditions under which the 'relevant' problems of technological progress were defined – or within which 'meanings' or 'frames' were attributed to technologies by different 'social groups' through a process of 'collective stabilisation and closure' – can be partly explained by reference to the different degrees of trust that existed between parties within aligned and non-aligned value chains and the different sanctions enforced within them (Dosi 1982, p.148; Pinch and Bijker 1987, p.23; Meyer and Schubert 2007, p.35). Stronger positive sanctions resulted in longer relationships, which contributed towards conditions of higher trust.

Notably, conditions of higher trust presented more numerous opportunities for communication and collaboration between buyers and farmers. As reliance between buyers and farmers increased over time – due to these longer relationships and due to consolidation within aligned pools – so did the opportunities for bilateral communication and collaboration. As a result, the definition of relevant problems – and of the meanings associated with technologies – more closely resembled a process of 'mutual negotiation' or *collective* stabilisation (see also **Observation 4**) between buyers and farmers within aligned value chains, when compared with non-aligned chains. However, it should be noted that the outcomes of such mutual negotiation

were increasingly constrained over time and, moreover, where benchmarking was used, participation within such negotiations was restricted to the best performing farms (see further below, 10.2). Therefore, conditions of higher trust provided a *small and diminishing number of farmers* greater influence over the direction of development of the farm, *towards a narrowing range of outcomes*. Only those farmers at the top of benchmarked pools are able to exert influence, over a diminishing range of alternatives.

High trust conditions were exemplified by the 'study tours' facilitated by Waitrose for its farmers. **Farmer K** recalled one such tour, to Canada: "We went to various really high producing herds ... I can vividly remember looking at these big Canadian Holstein cows ... and one of the Waitrose people said 'What do you think of these cows?' and I said 'Well, as far as I'm concerned, they are horrible!' ... And the reply was: 'I completely agree. That isn't what we want our farmers to be using' ... It just showed me that we were heading in the same direction as Waitrose."

The practice of benchmarking also reinforced such collaboration, providing a framework within which buyers' demands both influenced – and were influenced by – farmers' production approaches (i.e. because examples of 'best practice' that buyers hoped to spread across producer pools were developed by the best performing farms; see **Observation 4**). This resulted in conditions in which 'meanings' attributed to technologies were more likely to be developed through a process of collaboration between farmers and supermarkets, albeit the competition between farms engendered by benchmarking and cost-of-production pricing (and the creation of expectation and co-ordination effects that this created) resulted in a narrowing of frames around the models of those farms with the lowest production costs, meaning that, although the best performing farms (i.e. those with lower production costs) participated with supermarkets in a process of collective frame stabilisation and closure, the participation of other farms was marginalised (9.3.3.1; see further **Observation 4**, below).

Notably, benchmarking therefore served as a mechanism through which buyers achieved frame stabilisation and closure, for example through influencing farmers' mindsets regarding the benefits of competition, and supporting this through the use of sanctions (high, stable prices, and the threat of exclusion).

By contrast, within non-aligned pools, there appeared to be fewer opportunities, or incentives, for farmers to influence buyer beliefs and demands, as conditions of trust were low and sanctions were less powerful. When non-aligned farmers' beliefs conflicted with those of their buyers, they were more willing to switch buyer than to engage with buyers in attempting to

influence buyers' demands (the lower milk price offering less of an incentive to retain their contract; cf. **Farmer M**, 7.4 and **Farmer K**, 8.3).

Finally, it may be that the increased reliance and duration of relationships in aligned pools, outlined above, results in investment effects as the operation of these pools – including benchmarking and the resulting provision of research and extension services – represents an investment on the part of supermarkets. Such investment may increase in proportion with increases in the duration of relationships and levels of reliance. This provides a possible hypothesis for future testing.

OBSERVATION 4: *The high, stable base prices paid by the larger supermarkets were based upon the production costs of the farmers supplying them. This practice – together with the benchmarking that accompanied it – created expectation and co-ordination effects both within aligned producer pools, and across the wider production sector, influencing both directions and rates of change.*

Although aligned farmers suggested that benchmarking groups were 'diverse', it was clear that benchmarking and cost of production pricing created strong pressures upon farmers to emulate the best-performing farms in the group, meaning that large aligned producer pools (in which price was determined by reference to production costs) exhibited a tendency towards a homogenisation of production approaches over time.

There was, further, evidence that the 'best-performing' farms within aligned pools – i.e. those that other farms were seeking to emulate – tended to be larger and more intensive. Notably, intermediate aligned farms reported experiencing pressures to introduce changes to their systems (i.e. changes in *direction* rather than rate) in order to emulate more intensive farms (in the words of intermediate **Farmer C**: "I benchmark myself against these guys on the high output systems, and it makes me question whether our system is going to be viable"). By contrast, intensive aligned farms did not report similar pressures to emulate either intermediate or extensive systems.

When benchmarking *had* influenced intensive farms to introduce changes (within either aligned or non-aligned pools), farms were able to implement such changes within the boundaries of their current, intensive, systems, rather than by changing direction. For example, upon realising that the more extensive farms within his benchmarking group had significantly lower feed costs than him, **Farmer I** introduced 'zero-grazing', effectively further stabilising his system around a permanently housed model, through investment effects resulting from purchase of a 'zero grazing' machine (7.1).

The view that benchmarked, aligned pools tend towards homogenisation is further supported by:

- The observation that, although supermarkets did not demand *specific* production approaches or technologies, the pressure to continually reduce production costs may, over time, progressively restrict the available range of options for farms' future development. **Farmer E**, for example, had not been directed explicitly by Sainsbury's to halve the number of Shorthorns within her herd. Instead, pressures to reduce her production costs underpinned this decision ("the supermarket ... are *very* closely monitoring our costs of production ... and they want to get that down ... and having monitored cost of production with the supermarket for the last ... four [years]... the answer is that we need to reduce that number of native breeds"). Reducing the number of Shorthorns in the herd – which had been a distinguishing feature of the farm for generations – served to make the farm more closely resemble the Holstein-based system (see **Farmer H**, 9.1) that was more typical of aligned producers.
- The fact that farms within benchmarked pools could compare themselves directly against the best-performing farms in the pool across a range of production parameters, and could therefore more readily emulate the approaches of those farms (e.g. **Farmers C and F**; 9.3.3.1). Although all farmers claimed that they were constantly benchmarking themselves (informally) against other farmers, and that this influenced farm development, there was evidence that formal benchmarking within aligned pools – and the transparency it afforded around other farms' production costs – accelerated such development through the strengthening of expectation and co-ordination effects (supported by the threat of exclusion). **Farmer B** – who had been both an aligned and a non-aligned supplier – exemplified this, suggesting that being on an aligned contract meant that he had made efficiency improvements "a bit sooner" than he would have otherwise (9.3.3.1).
- The observation that benchmarking farms against each other was revealing areas of 'best practice', which buyers aimed to promote across the supplier pool through research and extension. Notably, underperforming farms supplying Tesco would be "offered help ... through consultancy" (**Farmer C**) to bring their production costs into line with the rest of the group. This provided an example of the influence of farmers upon buyers' demands within aligned value chains (see **Observation 3**, above) as supermarkets' support for (and influence upon) farms (through research and extension) would be informed by the approaches taken by the best-performing farms, which, as mentioned above, tended to be larger, more intensive operations. However, the

dissemination of best practice was also a key mechanism through which supermarkets achieved closure around technological frames, influencing the ways in which farmers framed the problems and solutions of dairy farming, and specifically farmers' mindsets regarding the benefits of competition (7.3.3.2 and 9.3.3.1) and the 'fairness' of cost of production pricing. Sanctions and conditions of trust served as further supporting mechanisms through which supermarkets achieve such closure.

Moreover, it may be hypothesised that the tendency towards consolidation within aligned pools over time (outlined above **Observation 2**), may serve to intensify these expectation and co-ordination effects amongst the remaining farmers within these pools, increasing the rate of farmers' progress towards goals and/or further inhibiting future changes in direction. This offers a potential avenue for future research.

Because of the desirability of supermarket contracts, *farmers within non-aligned value chains* also sought to emulate the performance of those within aligned producer pools (e.g. **Farmer O, Section 7.3.3.1; Farmer N 9.3.1.1**). Supermarkets therefore *directly* influenced the rate and direction of development of aligned farms and *indirectly* influenced the rate and direction of development of non-aligned farms.

These findings make an original contribution to the literature on the diffusion of innovation. They suggest that processes of homogenisation within aligned pools, and across the wider dairy farming sector, cannot be attributed purely to the 'bandwagon effects' envisioned by diffusion scholars. Abrahamson and Rosenkopf, for example, based their conception of bandwagon effects upon a critique of 'rational-efficiency theories', which "... assume that organisations rationally choose to adopt an innovation that is diffusing based on updated information about the innovation's technical efficiency or return." (Abrahamson and Rosenkopf 1993, p.489) They argued that such theories cannot explain the diffusion process unless various assumptions are satisfied, namely that:

"To influence nonadopters' decisions, information must flow through channels from early adopters to nonadopters. For this to happen, there must exist (a) information, (b) channels, (c) a propensity of early adopters to disseminate this information, and (d) a propensity of nonadopters to be influenced by it. If any of these four conditions is not met, then diffusion cannot be explained by rational-efficiency theories." (ibid. p.490)

Instead, they characterised bandwagon effects as occurring when organisations' decisions to adopt an innovation result from "... the sheer number of organisations adopting an innovation ... rather than their individual assessments of the innovation's efficiency or return" (ibid. p.487-491). In other words, bandwagon effects (often discussed interchangeably with expectation and

co-ordination effects; Dobusch and Schußler 2012) have a ‘self-fulfilling’ quality (Shapiro and Varian, 1999, p.13-14).

Significantly, the study findings demonstrate clearly that, within value chains for liquid milk, farms across the sector did not adopt technologies purely because of the ‘sheer number’ of other farms adopting those technologies. For example, non-aligned farmers emulated farmers within aligned pools because aligned farmers were in receipt of the highest prices for their milk, not because aligned farmers comprised the majority of farmers in the sector.¹⁹⁶ The degree of price variation within the market, and the considerable transparency around pricing, provided farmers with both the information necessary to assess the available returns to technology adoption and the incentive to adopt.

In contrast to the determinism implied by Abrahamson and Rosenkopf’s conception of ‘bandwagon effects’¹⁹⁷, the findings suggest that such effects were underpinned by human agency or deliberate action. For example, although benchmarking provided examples of the “... utility resulting from others following the same path...” (i.e. co-ordination effects; Dobusch and Schußler 2012, p.623), the practice of benchmarking was *itself* a deliberate act, underpinned in this case by supermarkets’ desire to direct farms towards specific outcomes (namely, improved production efficiencies to reduce costs, and increased data collection and monitoring of animal welfare and environmental performance metrics to satisfy consumer demands for product traceability).

Further, within aligned value chains for liquid milk, supermarkets provided the necessary channels for gathering and disseminating of information, through:

- Benchmarking, which offered a clear means of assessing both the extent of technological adoption amongst producer pools and the relative efficiency of different technological approaches, and
- Providing research and extension services based around the outcomes of benchmarking exercises.

Supermarkets also helped to establish the parameters along which technological performance was to be valued or assessed in the first place. This was evidenced by the observation that

¹⁹⁶ In fact, quite the reverse is the case: “because of the structure of the milk supply sector, only about 3% of milk producers are direct suppliers to retailers” (House of Commons 2015, p.15)

¹⁹⁷ See Dobusch and Schußler p.625, citing Shapiro and Varian (1999): “Self-fulfilling expectations are one manifestation of positive feedback economics and bandwagon effects.”

aligned farmers often adopted mobility scoring, in the first instance, not because they believed it would improve production efficiencies, or because other farmers were doing so, but in order to satisfy *supermarket demands*.¹⁹⁸ Indeed, farmers frequently reported that the performance benefits of innovation adoption had only become apparent *after* adoption, rather than acting as a driver for adoption.

It is significant that Abrahamson and Rosenkopf examined bandwagon effects within 'collectivities' of organisations, defining a 'collectivity' as "... a group of competitors such that each competitor knows when another competitor has adopted an innovation..." (Abrahamson and Rosenkopf 1993, p.488). While their analysis centred on the characteristics of organisations *within* collectivities that might result in bandwagons being joined (or not), it therefore did not include the contribution of powerful buyers (i.e. *outside* of collectivities who, moreover, help to define these collectivities to the extent that they determine the composition of aligned pools) towards such effects. However, this study offers clear evidence that powerful buyers make an important contribution to such effects.

The above discussion highlights the key role performed by supermarkets within the value chain for liquid milk. Indeed, the findings serve to enrich Dewick and Foster's depiction of retailers as the 'focal actors' within "... the milk production and distribution system..." (i.e. "... those with the greatest influence to drive innovation..." with the ability to "... stimulate ... innovation from suppliers upstream." (Dewick and Foster 2011; p.1-2) It offers a contribution towards an "... understanding [of] the role of 'focal actors'..." (ibid. p.2) through presenting an explanatory account of the interaction between farmers and powerful buyers, which may illuminate the ways in which "... existing industry structures and power relationships ... inhibit the emergence of new structures...", or not (ibid. p.1). Notably, the emergence of new structures is inhibited as aligned pools tend towards homogenisation as a result of benchmarking and expectation and co-ordination effects.

Moreover, the findings also contribute to their discussion regarding the extent to which retailers facilitate 'best practice dissemination' (ibid, p.1), for example through benchmarking. Dewick and Foster suggest that:

"The restructuring of the milk PDS [production and distribution system] around the supply chains of the supermarkets has led to a change in [the] provision of knowledge and demonstrates another growing element of their 'focal' role. Thus, over the last few years, major retailers have developed supplier-improvement programmes for their long-term supply contracts ... so a new mechanism for the spread of best practice has emerged." (ibid. p.7)

¹⁹⁸ Albeit these supermarket demands were themselves partly informed by evidence, from benchmarking, of the best practices of best performing farms (see **Observation 3**).

While Dewick and Foster argued that “... this mechanism may well be considered more discriminatory (or selective) – it is after all available only to those farmers supplying one or other of the major retailers...” (ibid., p.7), the findings of this study suggest that the supermarkets’ influence in disseminating best practice extends *beyond* the boundaries of their value chains, *further extending their power as ‘focal actors’*.

10.2 Distinctions between Types of Farm Systems

The following distinctions could be observed between farms operating different production systems, regardless of which type of value chain they functioned in:

OBSERVATION 5: *The influence of buyer demands upon farms varied according to the farm system in use. This can at least partly be explained by considering the following, related, factors:*

- *The degree of correspondence between buyer demands and system goals*
- *The varying influence of sanctions upon different system types*
- *The depth of changes implied by buyer demands, which varied by system type*
- *The “amount of technology” used by the system, and the resulting number and intensity of complementarity effects (Diederer et al 2003, p.332)*

Different farm socio-technical systems progressed towards different goals, and a specific buyer demand would therefore correspond with these goals to varying degrees. Broadly:

- Intensive farms progressed towards the primary goal of maximising output per cow/per milking robot (7.1)
- Extensive farms’ progressed towards the primary goal of minimising production costs per cow/litre of milk (8.1)
- Intermediate farms progressed towards a more diverse set of goals when compared with intensive and extensive farms (9.1).

Related to this, the mechanisms (chiefly sanctions) that buyers used in order to secure compliance with specific demands influenced farms in different ways and to different extents, depending upon the system in use.

For example, buyer demands for high (low) production were supported by high (low) milk prices, and corresponded closely (conflicted) with intensive farms’ progress towards the goal of maximising output. Intensive farms therefore responded readily to high prices by further intensifying production (increasing inputs per cow) and/or expansion. They responded to low prices by reducing herd size and/or purchased feed inputs. High, stable prices were sometimes

regarded by farmers as being essential for the continued functioning of both intensive and intermediate farms (e.g. **Farmer F, Section 7.3.1.1; Farmer D Section 9.3.1.2**). This was likely to be related to the higher variable costs associated with these systems, when compared with more extensive systems. As analysis of the Milkbench+ dataset revealed, mean variable costs per cow were £1,386.84 for Intensive farms, £1,034.51 for intermediate farms, and £847.94 for extensive farms.

High and low prices neither strongly corresponded, nor strongly conflicted, with the goals towards which extensive farms were progressing. Extensive farms typically responded to high prices through expansion (i.e. increasing herd size) rather than by increasing inputs per cow. Extensive systems were more resilient to low, volatile prices than intensive systems. In the words of **Farmer G**: “In the good years a high production system will probably make more money than we do, but in the bad years we will still make money”.

The influence of milk prices upon the rates of technological change was more pronounced in intensive production systems than extensive systems. The *sequence* of technological changes enacted by farms in response to price changes also appeared to vary by farm system. Intensive systems reported increasing feed inputs in the first instance in response to price increases, before later increasing herd size, whereas extensive systems reported increasing herd size alone.

Due to the diversity of goals towards which intermediate systems progressed, it was not possible to infer generalisations about whether high, stable and low, volatile prices corresponded, or conflicted, with the goals of intermediate farms *as a cluster*. Broadly, however, intermediate farms did appear to have a wider range of possible options for future development in response to milk price changes, being, in the words of **Farmer C**, “... in the middle of two systems.” The downside of this, however, was that intermediate farms appeared less able to either (a) fully capitalise upon conditions of high prices or (b) withstand low price conditions (e.g. **Farmer N, Chapter 9**).

With regard to the former, intermediate systems were often less able than intensive systems fully to capitalise on the high, stable prices paid under aligned contracts (see **10.1**) and were incentivised, under such conditions, to intensify. With regard to the latter, intermediate farms on non-aligned contracts appeared to be experiencing the greatest economic hardship within the prevailing conditions of low milk prices, enjoying neither the low input costs of extensive farms, nor the scale economies of more intensive operations to support them through those challenging conditions (in the words of **Farmer D**: “The middle ground ... is actually in some

respects the hardest place to be"). This created incentives either to intensify or extensify production.

This finding, regarding the greater flexibility of intermediate farms to pursue different approaches (9.1), is consistent with – and serves to explain – trends observed by AHDB Dairy / DairyCo¹⁹⁹, namely, that the majority of changes in direction amongst farmers have been from intermediate production systems towards either intensive or extensive production systems (as opposed to intensive or extensive farms moving towards more intermediate approaches). The relative ease with which intermediate farms were able to execute such changes can further be explained using the concepts of 'depth' of changes, 'core activities' (detailed below and previously covered in section 3.6.3) and 'amount of technology'.

'Depth' refers to "... the extent to which [governance] affects the core activities of individual parties in the chain..." as opposed to "... peripheral operations." (Kaplinsky and Morris 2001, p.32) The evidence gathered revealed that the depth of the changes associated with a particular buyer demand varied by system type, because core activities varied by system type (moreover, the technologies associated with such core activities were often specialised and 'non-transferable'; Dobusch and Schußler 2012 p.623). For example, although feeding cows was a core activity of all systems, changes to either feeding or breeding technologies would have a deeper effect upon intensive and extensive systems than upon intermediate systems, because the selection of breed was a more critical factor in the performance of intensive and extensive systems (which were aiming to maximise or minimise feed inputs per cow, respectively). Breeding changes could be less readily accommodated within intensive and extensive systems, compared with intermediate systems, because the cows used in these systems (in particular the high-yielding pedigree Holsteins) were specialised and non-transferable in character.

Similarly, although switching to an all-year calving model (e.g. in response to buyer demands for level production) presented challenges for all system types, such a change was less readily accommodated within (i.e. would affect more deeply) extensive systems than intensive systems (due to the former's greater reliance on grazing, which was a core activity for these farms). Notably – and returning to the discussion regarding the distinctions between aligned and non-aligned value chains (10.1) – because level production has become a higher priority for supermarkets (which are seeking to source all of their annual milk requirements from within their supplier pools, see **Observation 2**), extensive systems may either (a) prove less attractive to supermarkets recruiting farms, compared with other systems, and/or (b) find it less profitable to operate within aligned value chains in the future. Such pressures may drive some

¹⁹⁹ Personal communication 2/12/14

extensive farms to make changes to their socio-technical systems in order to meet buyer demands for level production (as seen in the case of **Farm K**), which may result in intensification of production.

Finally (and building upon the above discussion) farms' responses to buyer demands varied according to 'the amount of technology' they used, which showed considerable diversity between different dairy farm systems. Diederer et al regarded the "... amount of technology..." as "... the number of different technologies involved in the production process...", suggesting, for example, that one would expect a higher probability of innovation adoption within greenhouse horticulture than in arable farming, because the former uses a larger number of different technologies (Diederer et al 2003, p.332).

Putting to one side the observation that "... the number of different technologies involved..." will vary not only between different subsectors of agriculture (e.g. dairy vs arable), but also *within* subsectors (i.e. intensive and extensive dairy farms will each use a different number of technologies, see further below) the findings of this study suggest that the 'amount' of technology should incorporate additional considerations, and should correspond more closely to what Hughes termed 'mass' (Hughes 1983, p.15; 3.3.6). For example, herringbone milking parlours, rotary milking parlours and milking robots may each be regarded as a 'single' technology, and therefore would be equivalent to one another from Diederer et al's perspective. However, as the findings revealed, these milking technologies each involve varying degrees of capital investment, knowledge and skills, and interact in diverse ways (and to varying degrees) with other system components, introducing different complementarity effects (discussed further below).

The study findings therefore strongly suggest that a more complete assessment of the 'amount' of technology should incorporate more than a simple documentation of the 'number of technologies' used, but should also consider:

- Differences in the (physical) 'obduracy' (Pinch and Bijker 1987, p.xxii) of these technologies and, related to this, distinctions between technological 'hardware' and 'software' (with 'software' taken to include not only process technologies, but also the knowledge, skills and experience embedded in farm employees). Such distinctions would therefore capture differences between, for example, housing and 'crayons' used in heat detection. Housing and crayons might each be regarded as a 'single' technology, but the former has a considerably larger and more enduring physical footprint on the farm, is therefore more difficult to remove once introduced, and so represents a larger potential obstacle to farmers' ability to respond to buyer demands.

- Related to this, the capital value of technologies (and the resulting investment effects associated with technologies), including depreciation. Again, in the example above, buildings are considerably more expensive than crayons, and would accordingly incur much stronger investment effects (albeit these investment effects would diminish over time as the buildings fall into disrepair and/or need replacement or improvement, meaning that the influence of buyer demands may also depend upon the timing of such demands relative to time horizons for investments in new technologies).
- The complementarities (both number and intensity) associated with technologies: A single technology may interact with several other technologies, or with none at all. The evidence suggests that the former case will present a larger potential obstacle to a farmer's ability to respond to buyer demands than the latter. This relates in turn to the issue of 'core activities', discussed previously. Where a technology performs a 'core' activity, it may be more likely to be characterised by a larger number of complementarities and/or more intense complementarities. It is conceivable that a single strong complementarity between two technologies that perform a core activity might present a greater obstacle to compliance with a buyer demand than numerous weak complementarities between several technologies performing peripheral activities. Finally, technologies involved in core activities are more likely to be related to (i.e. to result from and/or in) actors' skills, knowledge and associated beliefs (see 'complexity', below, or how readily technologies can be incorporated into the system, given existing bodies of knowledge).

While simpler metrics such as 'numbers of technologies' or capital expenditure offered a straightforward numerical measure of the 'amount of technology', the importance of incorporating the contribution made by complementarities was illustrated by the fact that many of the farmers interviewed cited their mobile phones as the 'most important technology' on the farm; by no means the most expensive technology, but valuable by virtue of performing a 'core' activity and through interacting with numerous other technologies – from receiving data regarding milk quality results, to communicating with (receiving text messages from) milking robots, to monitoring closed circuit TV images of cows – therefore resulting in complementarities.

A return to the example of milking technologies, introduced above, demonstrates how these additional concepts and dimensions help to explain the distinctions between farmers' responses to buyers' demands. For example, milking robots are expensive, obdurate (installed into, and

requiring modifications to, housing), were involved in a 'core' activity, created strong complementarity effects with feeding, housing and breeding technologies, required the development (and embedding) of new knowledge and skills (e.g. both for farmers in terms of learning how to operate and maintain the machinery, and for cows, which 'learn' to be milked, see **Farm O**, 7.2), and were 'specialised and non-transferable' in nature. As a result, once introduced, milking robots presented a considerably larger barrier to directional change than herringbone parlours (which – although expensive, obdurate and involved in a core activity – lacked the same intensity of complementarity effects). Robots were therefore a more significant factor for farms than herringbone parlours when considering whether (or how) to comply with buyer demands.

Although all systems exhibited complementarity effects between system components, the number and strength of these varied by system type, making different systems more or less responsive to demands requiring change. Broadly:

- Intensive farms were characterised by the use of a 'large amount' of technology (in terms of numbers of different technologies, their capital value, and the number and intensity of complementarities between technologies) compared with extensive and intermediate systems. This potentially inhibited the ability of intensive farms to change direction. This was exemplified by the interactions between milking robots, permanent housing, intensive feeding and year round calving: complementarities between these technologies resulting in particularly pronounced stabilisation in intensive systems.

The practice of benchmarking (which militates against diversity) within aligned value chains (in which more intensive farms tended to be the 'best performing', and which other farms sought, therefore, to emulate; see **Observation 4**) therefore tended to amplify this stabilising effect, and to further limit intensive systems' scope to diversify or change direction within aligned pools.

- Extensive systems were inhibited from moving to a very intensive system in part due to the high cost of the necessary capital investment in new housing and additional feed, and in part because of the rigidities of 'beliefs'. On the other hand, due to their low inputs per cow, extensive farms could expand rapidly, although expansion beyond certain limits often required the introduction of new milking parlours, resulting in investment effects that inhibited subsequent reductions in herd size.
- Intermediate systems, by contrast to intensive and extensive systems, were characterised by trade-offs and tensions between system components, rather than by

complementarities. The relatively weaker / less well-defined nature of complementarities within intermediate systems provided an explanation of these farms' greater responsiveness to market changes, including changes in buyer demands.

The finding that the correspondence between buyers' demands and farms' progress towards goals varied according to the farm system in use (with intermediate farms having a greater diversity of scope for possible directions of future development compared with intensive and extensive farms) further illuminates the contribution to the SCOT literature outlined already in **Observation 3**.

As outlined above, aligned value chains were characterised by higher trust and therefore greater collaboration in the "... collective stabilisation and closure..." of technological frames (Meyer and Schubert 2007, p.35). The discussion above suggests, however, that the degree to which the outcomes of such collaborative efforts were constrained varied according to *system type*, with intermediate systems exhibiting a greater diversity of possible frames than intensive and extensive systems, which were more constrained. This is significant, given that aligned pools were characterised by a tendency towards homogenisation around an increasingly intensive production model. It implies that, although higher conditions of trust in aligned chains resulted in the potential for mutual negotiation of frames, the outcomes of such negotiation were increasingly constrained. While farmers in aligned chains may have had more opportunity to become involved in determining the outcomes of development (compared with those in non-aligned chains) their available range of outcomes was potentially narrower. Moreover, where benchmarking was used, such involvement was restricted to the best performing farms.

An additional area for further research is the influence of consumers (see above, **Observation 2**) within this process of collective stabilisation and closure, in the light of the distinctions noted between different farm systems. For example, intensive farms were particularly sensitive to consumer concerns regarding the housing of cattle (e.g. **Farmer F, Chapter 7**), which influenced their deployment of technologies, particularly with regards to data collection and monitoring with regards to animal health and welfare metrics. Moreover, consumer perceptions had clearly influenced intermediate **Farmer N's** decision not to invest in robots, due to the public's perception regarding the permanent housing of dairy cows (9.2).

The above discussion also highlights once again the fact that milk prices are 'high' or 'low' relative to market averages (as outlined above 10.1), but also relative to *input costs* (which vary

by system type). Moreover, different technological configurations mean that particular buyer demands may be accommodated within a diversity of systems in a variety of different ways (e.g. not invariably resulting in intensification). This reaffirms the broader contribution that analysing the influence of buyer power upon producers at the *subsector* level, rather than at the sector level, can yield more valuable insights (and avoid the risk of overlooking the diversity of responses of producers to given buyer demands).

These observations tend to support Leiponen and Drejer's suggestion that "... contrary to prevailing assumptions ... [within the technological regime literature] ... industries are not at all uniform in terms of how [the] firms [within them] innovate." (Leiponen and Drejer 2007 p.1221) There is, instead, a degree of 'within-industry variation' and 'strategic diversity' amongst firms, resulting in "... similarly behaving subsets of the industry." (ibid. p.1222-3) Put differently, although dairy farming may be considered, *broadly*, as a "supplier-dominated" sector (cf Pavitt 1984), the degree of sensitivity of individual farms to downstream buyers – and the resulting impact upon technological decision making – may vary considerably, in particular according to the "... amount of technology used..." by farms, but also as a result of the wide degree of price variation for what is essentially a fairly uniform / homogeneous product (see above, **Observation 1**).

The findings make a similar contribution towards the literature regarding the diffusion of agricultural innovations. Rogers, for example, suggested that "complexity" or "... the degree to which an innovation is perceived as difficult to understand and use..." is an important factor influencing the diffusion of innovations (Rogers 1983, p.15). By performing analysis at the farm level, rather than the level of the technological artefact, the study highlighted ways in which the degree of complexity of a particular technology will *vary* from farm to farm, depending on the prevailing technological approach and technological configurations being used (and the farmer's associated knowledge, skills, etc). For example, grazing was demonstrably more difficult or complex to introduce on farms that used milking robots because of the need for the cows to 'learn' to graze' (e.g. **Farm I, 7.2**) and the difficulty of ensuring access to robots (**Farms O, I, 7.2; Farmer J, 9.1**), than on farms that used conventional herringbone parlours.

Further, the findings may contribute towards the diffusion literature aimed at understanding the impact of farm heterogeneity upon innovation adoption through the use of "... decision theoretic models of innovation..." (i.e. "What makes a farmer adopt an innovation?" Diederer et al 2003). Once again, the findings imply that heterogeneity should be examined at a more granular level that has often been applied within such studies, which, when looking at the farm-level, have often focused on variables such as farm size, location, farmer education, or age

(Sunding and Zilberman, p.231-4) as opposed to specific production approaches or technological configurations.

10.3 Summary

The direction of socio-technical system reproduction *as a whole* was towards greater intensification of production across the research period (farms that were 'intensive' at the outset intensified, some extensive farms extensified, while intermediate farms more frequently tended towards intensification than towards extensification).

Farms attempted, as far as possible, to comply with buyers' demands within the boundaries of their current production systems, due to the action of positive feedbacks associated with these systems. When buyers' demands corresponded closely with farms' progress towards existing goals, such demands were broadly successful in influencing farms' progress, increasing the rate of progress towards those goals. When there was a lack of correspondence between farms' progress towards existing goals and buyers' demands, buyer demands influenced the direction of farm progress only when supported by strong sanctions and/or conditions of trust within the value chain. The requirement for strong sanctions and/or conditions of trust increased with the 'depth' of the changes associated with buyers' demands (i.e. the more they impacted farms' 'core' activities). Sanctions and conditions of trust could therefore be regarded as mechanisms through which actors (farmers and buyers) achieved collective stabilisation and closure around technological frames.

Chapter 11: Conclusions

This study has provided new insights into patterns of technological change in the UK dairy farming sector, in particular highlighting how and to what extent powerful buyers – including supermarkets – have influenced farmers’ technological approaches within value chains for liquid milk.

As explained in **Chapters 1 and 2**, the impact of retail market concentration upon the food system is a subject of considerable public interest and debate. For example, it is often suggested that, due to their power, supermarkets are able to capture a disproportionately large share of the retail price of food products, therefore exerting significant pressure upon the margins of suppliers and producers upstream. Larger, more intensive producers may be better able to withstand such market conditions (Lang & Heasman 2004). The concern, therefore, is that supermarket power may contribute towards a homogenisation and intensification of production, and a corresponding lack of diversity (and resilience) across the agricultural sector.

The dairy farming sector, specifically, has witnessed considerable concentration and intensification since the deregulation of the UK’s milk market, following the abolition of the Milk Marketing Board in 1994 (**Chapter 2**). On the one hand, this may represent merely the continuation of a longer-running trend towards fewer, larger, more productive farms (Empson 1998, p.78), which may be explained by incremental improvements in farming technologies (Brassley 2000; Bieleman 2005; Lampe and Sharp 2015). On the other hand, such patterns might be attributable to the power and influence of supermarkets – often evidenced by successive rounds of ‘price wars’, during which supermarkets have been accused of selling milk as a ‘loss leader’ (House of Commons 2004, Ev34). Some argue that this has resulted in a decline in the share of the retail price of milk captured by farmers, leading them to expand and/or intensify production (Boulton et al 2011).

Complicating matters, supermarkets have responded to criticisms of such practices by developing dedicated supplier pools. As **Chapter 5** demonstrated, post-1994, the market for milk has exhibited increasing complexity: the raw milk produced by dairy farmers supplies a huge number of different end markets and, moreover, there is a considerable diversity of contractual arrangements governing the relationships between farmers and buyers, a broad range of different pricing mechanisms, and substantial variation in the prices ultimately received by farmers.

This study has illuminated this discussion by distinguishing the influence of buyers' demands from the influence of longer-run technological changes unrelated to the influence of buyer power. To do this, the study developed an analytical approach based around an evolutionary perspective of technological change (**Chapters 3-4**). This theoretical foundation offered potential advantages over 'linear' perspectives, in which technological change results from variations in a single factor input, or is driven by *either* 'market pull' or 'science push'. Instead, change was regarded as being the product of interactions and feedbacks between a number of interrelated technological and non-technological components, comprising a 'socio-technical system'. Because this perspective viewed technological change as both contingent and situated, it provided a means of accounting for heterogeneity in farms' responses to prevailing market forces. It also served to characterise technological change within socio-technical systems as an inherently-contested process of 'reproduction', alternating between periods of relatively stable 'path dependent' change, and periods of more disruptive change.

To avoid potential shortcomings associated with evolutionary models – namely, their 'circular' character (Millstone 2010, p.294) – the framework placed greatest emphasis upon interactions between actors (buyers and farmers) and technologies, while other components (resources and institutions) provided a 'background' against which – or 'medium' through which – these interactions occurred. Conceptual tools were borrowed from the global value chains (GVC) literature in order to enrich the analysis of these interactions. Moreover, to further illuminate the contested nature of reproduction, conceptual tools were incorporated into the framework from the literature on the social construction of technology (SCOT).

This yielded a novel theoretical framework that aimed to accommodate both 'path dependent' processes and 'deliberate' actions, in order to provide a means of explaining not only the ways in which 'normal' technological change differed from farm-to-farm but, moreover, to explain variations in the influence of buyer demands upon different farms. This framework was used to answer the question: *In which ways, and through what mechanisms, does buyer power influence the reproduction of farm-level socio-technical systems for the agricultural production of liquid milk in the UK?*

11.1 Results Overview

11.1.1 Empirical Contributions, Predictions and Policy Implications

The framework was applied to the analysis of a range of case studies, revealing several novel insights that alternative approaches might have overlooked. Further, the observations regarding system change within the dairy sector across the study period, highlighted in **Chapter 10**, inform predictions about the future of the UK dairy sector and imply some policy responses to such possible future outcomes.

11.1.1.1 The Direct and Indirect Influence of Supermarkets: Contributions

The findings revealed clear sector-level patterns of system change over the study period; broadly speaking, a move towards greater intensification of production across the research period (farms that were ‘intensive’ at the outset intensified, some extensive farms extensified, while intermediate farms more frequently tended towards intensification than towards extensification; see **10.1**). This was consistent with DairyCo/ AHDB Dairy’s suggestion that farms were moving away from what this study calls ‘intermediate’ systems, towards either ‘intensive’ or ‘extensive’ models of production, rather than vice versa (see **10.2**).

Significantly, the study identified the influence of powerful buyers upon these patterns, uncovering evidence that **supermarkets exerted both a *direct* influence upon the (‘aligned’) farms that supply them, and an *indirect* influence on other (‘non-aligned’) farms** (see **Sections 7.3.3.1; 9.3.1; 10.1**) and attributing this to the stronger sanctions and higher levels of trust present within aligned value chains (see **10.1**), which were related to the degree of price variation and the diversity of contractual arrangements available in the market. Therefore, the influence of supermarkets resulted in an intensification and homogenisation of production amongst their direct suppliers over the study period (e.g. **Farms C and E, Chapter 9**), *as well as* amongst farms *outside* of supermarket value chains, often due to expectation and co-ordination effects associated with benchmarking farms on the basis of their production costs, and with research and extension activities based on these benchmarking exercises (**10.1**).

11.1.1.2 The Direct and Indirect Influence of Supermarkets: Predictions

Looking to the future, a continuation of this trend may introduce new risks to the dairy sector or exacerbate existing ones. Broadly, because of the greater use of purchased feed inputs within intensive systems, if the trend towards sector-level intensification persists then the sector’s resilience to economic stresses and shocks may be undermined as farms become increasingly exposed to movements in feed input prices. The implications of this potential outcome are particularly striking given the UK’s decision to exit the EU, following the referendum of 2016, which may exacerbate the challenges facing UK farmers, within a current climate of

protectionism (Lang, Millstone and Marsden 2017). Moreover, this development should be viewed within the broader context of the repeated ‘dairy crises’ and steadily declining farm numbers in the UK (see **Chapters 1 and 2**), which provide an indication of the economic challenges that the dairy sector has endured in recent decades.

Of particular note are the risks resulting from the *indirect effects* of supermarket demands upon *non-aligned farmers*, who may seek to emulate aligned farms with a view to securing aligned contracts (evidenced by Tesco’s ‘waiting list’ of farms, **9.3.1.1**), potentially adopting production models unsuited to their current contracts (see **Chapter 5, footnote 41**; and **11.1**). The farmers interviewed in this study often regarded high, stable prices as being essential for the functioning of intensive and intermediate systems, whereas extensive systems were more resilient to low, volatile prices (see **10.2**). Therefore, whereas technological changes implemented by aligned farmers (i.e. moves towards greater intensification) may be compatible with their supermarket contracts (which pay high, stable prices) the same changes may be less compatible with the contracts of non-aligned farmers (which pay lower, more volatile prices). Non-aligned farms that intensify production in the hope of securing an aligned contract may, in the absence of the high, stable price received under an aligned contract, be more exposed to the economic impact of input price increases (e.g. in feed or other inputs) and less resilient to future economic stresses and shocks.

The trend towards intensification may also exacerbate environmental impacts associated with intensive production models (see **2.3.2**) at both the sector and individual farm level, particularly if farms were to pursue intensification under circumstances in which such an approach is incompatible with the available environmental resources. For example, if local climate and geographical conditions are not able to support the increased waste management burden associated with the intensive, year-round housing of cattle, then a move to such a system may create a heightened risk of local environmental pollution and/or disease. The influence of environmental resources will be recalled from **7.2**, **8.2** and **9.2**, in which examples were provided of the ways in which, historically, farms had been constrained by prevailing local environmental resources and conditions. Pressure to emulate larger, intensive aligned farms may be challenging this pattern, driving farms to pursue approaches that are unsuited to their local environment (see **2.3.2**).

The trend towards intensification should be considered in conjunction with the study’s finding that intensive systems were exhibiting evidence of ‘reverse salients’, which implied that they were reaching the limits of further intensification (**7.1**). This finding suggests that there is an

inherent – and increasing – tension between, on the one hand, the drive towards intensification and, on the other hand, the biological and economic limits of the intensive model of production.

11.1.1.3 The Direct and Indirect Influence of Supermarkets: Policy Implications

The above observations and predictions imply that the influence of supermarket power may be more pervasive than might otherwise have been assumed (see, e.g. 10.1). This suggests that policymakers should place greater attention upon the wider impacts of supermarket power (i.e. beyond their impact on their direct suppliers), and should consider the consequences of ‘expectation and co-ordination effects’ resulting from the establishment of dedicated supermarket-aligned producer pools, which have created a system of ‘haves’ and ‘have-nots’ within the sector (10.1).

Notably, reviews of the effects of the oligopolistic power of supermarkets have often considered asymmetries in price transmission between participants in the milk value chain but have not focused on the type of indirect sector-level effects, such as co-ordination and expectation effects, considered within this study (Smith and Thanassoulis 2008). Further, such reviews have often restricted their scope to relationships between supermarkets and their *direct* suppliers (i.e. processors), overlooking the implications of supermarket power for the broader supply chain. For example, an investigation into the groceries sector by the Competition Commission in 2008 examined movements in farmers’ and retailers’ shares of the retail price for milk, concluding that increases in the latter demonstrated increases in retailers’ power relative to farmers’ power (Competition Commission 2008, Appendix 9.3).

On the recommendation of the Competition Commission’s investigation – which had concluded that “some large retailers were transferring excessive risk and unexpected costs to their *direct* suppliers” (GCA 2018, p.10, emphasis added) – the UK Government introduced the Groceries Supply Code of Practice in 2010 (GSCOP), and established the Groceries Code Adjudicator (GCA) in 2013 in order to regulate relationships between supermarkets and their direct suppliers. However, indirect effects of supermarket power, and indirect relationships – such as those between supermarkets and farmers upstream from processors – were not within the scope of either the GSCOP or the GCA.

Between 2016 and 2017 the UK government consulted on extending the GCA’s remit to cover indirect suppliers, such as primary producers and farmers, and to provide them with similar levels of protection (BEIS 2016a, b). Notably, the consultation identified “a significant pattern of unfair or unclear terms and conditions in contracts between producers and the processors,

slaughterhouses, or manufacturers that they supply. *These concerns were particularly prominent in the dairy sector.*" (HM Government 2018, p.6; emphasis added). However, it concluded that, "there was not enough evidence to support extending the remit of the GCA" although "some unfair trading practices were identified".²⁰⁰ Instead, the consultation proposed introducing "compulsory written contracts in the dairy sector in 2018" to provide "extra transparency and certainty for dairy farmers." (ibid.). At the time of writing, the government plans to consult on the necessary secondary legislation to implement and regulate such contracts.

The explanation of indirect influences provided by this thesis represents a novel contribution to the field and one worthy of further examination. It also suggests that policymakers should consider again broadening the scope of GSCOP and the GCA's remit and powers to address the relationship between supermarkets and *farmers* and, moreover, to address the indirect effects of supermarkets upon non-aligned value chains, for example, permitting farmers to refer cases to the GCA, and enabling both direct and indirect influences of supermarket power to be factored into assessments of supermarket power.

The finding that supermarkets indirectly influenced non-aligned farms reveals a further significant policy implication concerning the 'privatisation of extension services'. The finding indicates that **the research and development activities sponsored by supermarkets, ostensibly in support of their supplier pools, may have broader reach** than other analyses have suggested (see 10.1). Indeed, whereas some have described supermarkets as 'focal actors' within value chains (i.e. "those who have significant market power and/or can stimulate eco-innovation beyond the boundaries of their own organisation"; Dewick and Foster 2007, p.2) the findings of this study demonstrate that supermarkets in practice stimulate innovation *beyond the boundaries of their own value chains*.

This raises the policy questions: who is driving the technological research agenda within the UK dairy sector? Who 'frames' the 'problems' of technological search and how and by whom are the approaches to solving these problems selected? Moreover, given that supermarkets account for a narrow – albeit significant²⁰¹ – segment of the market, are other voices marginalised within this process of negotiation?

This study also demonstrated clearly that **the ability of supermarkets to influence farms (both directly and indirectly) relied heavily upon the existence of considerable price variation**

²⁰⁰ <https://www.gov.uk/government/consultations/groceries-code-adjudicator-extending-its-remit>.

²⁰¹ 'Narrow' in terms of their requirements (i.e. level year round supply of liquid milk); 'significant' in terms of their size (i.e. millions of customers).

within the market (with supermarkets paying higher, more stable prices than other buyers; see **7.3.1.1, 8.3.1.1, 9.3.1.2, 10.1**).

Significantly, this explanation runs counter to analyses focused purely on distributional outcomes (see above), i.e. “the gap between farmers’ prices and ... retail prices” at the sector level (Lang & Heasman 2004, p.149). Such arguments may exhibit a tendency towards a simple, linear structure (i.e. ‘supermarkets capture a disproportionate amount of the margin from the sale of milk, thus putting downward pressure on producers’ margins, thereby forcing the smallest producers out of business’). They may fail to capture fully the complexities and dynamics of the market (namely, as demonstrated in **5.2.3**, the ways in which distributional outcomes vary *at the farm level*, as a result of the different prices paid under different contracts and due to the different ways in which these prices influence different production systems because of the different complementarity effects associated with these different systems; see **10.2**) and may therefore imply inappropriate or inadequate policy responses.

Further, such linear, sector-level accounts may be readily repudiated – and dismantled – by supermarkets, which may contend, in their defence, that they pay consistently the highest prices in the market (see e.g. **Figures 7a, 8a, 9a**).

This study offers another explanation, which may be less readily rejected, and which implies a different policy response. Farms that supplied supermarkets expanded and/or intensified *because* they received the highest, most stable prices (see e.g. **Farms F and M, 7.3.1.1; Farm K 8.3.1.2; and Farms C, D and E, 9.3.1.2**). Due to the degree of price variation in the wider market, and the volatility of these prices, non-aligned farms either: scaled back production through reducing herd size (e.g. **Farm M, 7.3.1.3; Farm N, 9.3.1.2**), extensified production in order to reduce (typically feed) input costs (**Farms B and J, 9.3.1.2**), or sought – as a result of expectation and co-ordination effects – to emulate aligned farms in the hope of securing a supermarket contract (**Farm O, 7.3.3.1**).

Although efforts have been made to improve the process of price determination within contracts for the sale of milk (e.g. through the voluntary code of best practice for contractual relationships; DairyUK 2013), this finding suggests that further policy efforts should address the issue of *price variation* within the milk market. Once again, the finding that supermarkets influence indirectly the production approaches of non-aligned farmers is of particular concern, given that cost-of-production pricing within aligned value chains has effectively ‘decoupled’ supermarket prices from demand (see **10.1**), whereas the prices received by non-aligned farms remain coupled to demand (within a broad range of commodity markets). By seeking to

emulate the approaches of aligned farmers, non-aligned farmers may be pursuing production approaches that are not suited to their contractual arrangements and/or local environment (see above). Moreover, extreme price variation in the market meant that aligned farmers (in receipt of the highest prices) appeared relatively unconcerned about the decoupling of price from demand, or about the fact that cost-of-production pricing results in constant downward pressure on prices over the longer term (see e.g. **Farm O 7.3.3.1**; also see further below **11.1.1.4**).

Further, these findings – while highlighting the fact that distributional outcomes vary between different value chains and therefore affect farmers to differing degrees – also emphasise the need to examine more closely power and distributional outcomes across the entire length of value chains (i.e. not simply between supermarkets and farmers). Of particular interest are the margins captured by *processors*, given that processors operate across many of different value chains for milk (i.e. aligned liquid, non-aligned liquid and manufacturing).

The fact that processors act as ‘contract processors’ within aligned chains, and that supermarkets ‘play processors off against one another’ (**9.3.1.1**; **9.3.1.2**) raises the question of whether supermarket price wars have served to reduce processors’ margins, and whether processors consequently pass associated losses on to their non-aligned farmers, who effectively subsidise aligned farmers. This, in combination with the findings regarding the effect of price variation within the market, suggests that policymakers might consider whether processors should be obliged to pay farmers a similar price for similar products.

11.1.1.4 The Evolution of Aligned Pools: Contributions

Related to the above, a further significant contribution of this study concerns the **inherent tensions within the aligned-segregated pool model** (see **10.1 Observation 2**). For example, in the absence of effective limits on production, aligned producer pools exhibited a tendency towards consolidation and overproduction in the longer term (with one Sainsbury’s supplier, for example, claiming that the supermarket now ‘buys more milk than it sells’; **9.3.1.2**). This raises questions about the long-term sustainability of such pools as currently constituted, particularly given the cost to supermarkets of operating them. Indeed, the study found evidence that supermarkets were developing measures that might provide greater control over production levels, with Tesco, for example, introducing a policy of terminating the contracts of its worst-performing farms; an approach that, taken to its logical conclusion, would result in further consolidation and an ever-decreasing number of ever-larger farms within the pool.

Another tension within the aligned pool model (where cost of production pricing was used) concerned the drive to constantly reduce production costs while maintaining a level annual supply of milk. As discussed above, intensive farms were encountering reverse salients (11.1.1.1) in the form of decreasing returns to intensification (7.1; 7.3.3.1) and were often responding to these through increasing the component of home grown forage and grazed grass used on the farm, in order to reduce production costs and exposure to the volatility of price movements in feed inputs. However, just as greater use of purchased feed runs counter to reducing production costs, so greater use of grazed grass and home grown forage potentially runs counter to achieving a level annual profile of milk (because grass growth is not level all year round).

11.1.1.5 The Evolution of Aligned Pools: Predictions

A continuation of Tesco's policy of eliminating its worst-performing farms seems likely to result in increased pressure on those remaining farms to emulate the best-performing (typically largest and most intensive) farms, potentially exacerbating the trend towards consolidation and intensification. Looking ahead, other supermarkets may introduce similar methods of limiting or controlling production volumes, with similar effects.

However, in spite of this trend towards consolidation and intensification – and the indirect influence of supermarkets upon non-aligned farms, outlined above (11.1.1.1 – 11.1.1.2) – the analysis does not support the view that supermarket influence will drive the UK dairy sector inexorably towards a 'megadairy' system. The analytical framework considered the degree of 'reliance' that parties in the value chain have upon one another (3.6.3) and implied that it might be against supermarkets' interests to become increasingly reliant upon a diminishing number of ever-larger suppliers as this would concentrate risk in the supply chain and enhance the bargaining power of farmers within negotiations. It suggested that megadaeries at the scale envisaged at Nocton in Lincolnshire (2.3.2) would represent such a sizeable proportion of a supermarket's milk needs as to prove unattractive from the supermarket's perspective (10.1, **Observation 2**).

Further, megadaeries would present a significant reputational risk to supermarkets, potentially undermining the 'PR value' of aligned value chains, as public statements made by supermarkets at the time of the Nocton application suggested.²⁰² This PR value lies primarily in the greater transparency and control that aligned value chains permit, in response to increased

²⁰² <https://www.independent.co.uk/life-style/food-and-drink/news/supermarkets-turn-noses-up-at-megadairy-milk-2137056.html>

consumer demand for these (see 10.1, **Observation 2**). With this in mind, looking ahead, it seems likely that retailers will:

- Monitor and review consumer perceptions and awareness of aligned value chains, and assess the degree to which these value chains are serving their purpose of satisfying consumer demands for greater transparency and control
- Monitor and review consumer demands, including the potential for these to change, particularly within the context of the UK's decision to exit the EU (Lang, Millstone and Marsden 2017), and whether this necessitates changes to aligned value chains.

It is likely, therefore, that, in addition to seeking to control volumes, supermarkets will maintain their efforts to drive down farmers' production costs and will continually adjust the demands they make of farmers (e.g. around animal welfare) in response to perceived changes in consumer demand. Such changes may introduce inconsistencies between supermarkets' demands. For example, during the period covered by this study, Waitrose was demanding a level production profile from its farmers, while simultaneously demanding a minimum period of annual grazing (10.1).

A final trend associated with the evolution of aligned pools concerns the erosion of cost of production prices as a result of benchmarking. There are at least two possible outcomes of this trend. The analysis suggests that supermarkets are able to influence farmers due largely to their higher, more stable prices. If these prices exhibit a constant downward trend, due to benchmarking, then, *ceteris paribus*, the influence of supermarkets may diminish as alternative, non-aligned prices become (relatively speaking) less unattractive. Alternatively, it may be that processors choose to reduce their prices in response to reductions in supermarket cost of production prices, which could trigger a future sector-wide milk price crisis.

11.1.1.6 The Evolution of Aligned Pools: Policy Implications

In the light of the government's intention to introduce compulsory written contracts in the dairy sector, and to consult on the secondary legislation required to implement these, policymakers should bear in mind the longer-term direct and indirect influences of cost of production pricing and benchmarking.

Notably, if the intention behind compulsory contracts is to introduce greater "transparency and certainty" in response to "unfair or unclear terms and conditions in contracts", (HM Government 2018, p.6) then policymakers might consider whether the constant downward trend of cost of production pricing represents a 'fair' outcome for farmers, in particular given

the considerable information asymmetries inherent in this method of price determination (9.3.3.1). Further, they might consider the impact of constant price erosion upon both aligned pools and (given the indirect influence of supermarket prices upon non-aligned pools) the wider sector (for example, the potential for a sector-wide milk price crash if processors choose to lower their prices in tandem with reductions in supermarket cost of production prices).

11.1.1.7 Emerging Opportunities for Product Differentiation: Contributions

The reverse salients discussed above imply that intensive systems are beginning to cut production costs, for example, through making greater use of grazed grass. This may be part of a broader recognition within the industry of (and response to) the trends towards consolidation and homogenisation observed above, and the associated threat to the resilience of farming models to feed input price movements. In parallel with this has been the emergence of farmer-led initiatives, for example the Free Range Dairy Network, which may be viewed as a response to the price variation in the market discussed already (11.1.1.1) and to the dislocation between the on-farm production of milk and the end use to which it is put (5.2.2). Such initiatives represent an effort on the part of farmers to both introduce greater product differentiation, to shift power away from the retailers, and to move towards a new socio-technical system.

It is significant, in the context of this study, that this effort to increase farmers' power is based around production technologies, tying both product differentiation, and the premium represented by that differentiated product, to the mode of production. Again, such developments (and their likely outcome) should be viewed in the light of the evolving consumer context (e.g. will such products as 'free range milk' command a premium or be viewed as 'too expensive' in a post-Brexit UK?).

11.1.1.8 Emerging Opportunities for Product Differentiation: Predictions

Whether such initiatives gain in popularity will depend upon how effectively they are able to communicate with and educate consumers, a challenge that may be considerable given that (as this study demonstrates) there is a huge variety of possible approaches to dairy farming, rendering agreement upon (and understanding of) 'free range' standards difficult in both theory and practice.

11.1.1.9 Emerging Opportunities for Product Differentiation: Policy Implications

Ensuring a diverse and resilient dairy sector may require the creation of an environment in which a range of different production and marketing models are able to successfully co-exist.

Policymakers might consider working with industry to endorse or support the development of standards including those being pioneered by groups such as the Free Range Dairy Network, facilitating greater transparency around such standards and improving consumer awareness.

11.1.1.10 Trust within Value Chains: Contributions

Finally, the analysis also revealed **the differences in conditions of trust that exist within aligned value chains compared with non-aligned value chains**, as well as the results of these differences. Notably, supermarket value chains were characterised by higher conditions of trust, and longer, more collaborative relationships compared with the value chains of other buyers (cf. **Farmer M, 7.4** and **Farmer K, 8.3**). Although this meant that farmers in aligned chains were more involved in determining the outcomes of technological change, they were selecting from a narrower available range of outcomes (due in part to the homogenisation within aligned pools, resulting from expectation and co-ordination effects created by benchmarking; e.g. **Farms C and E, Chapter 9**). Moreover, only those farmers at the top of benchmarked pools were able to exert influence over the direction of development of the farms within the pool, meaning that conditions of higher trust provided a *small and diminishing number* of farmers greater influence over the direction of development of the farm, *towards a narrowing range of outcomes*.

11.1.1.11 Trust within Value Chains: Predictions

A continuation of the trend outlined above implies that, as trust within aligned pools increases over time, this will result in a progressively narrowing ‘elite’ of farms within these pools. This may lead to alternative voices being marginalised, reducing the potential for diversity within these pools.

However, as noted already, aligned pools in which the milk price is determined by reference to the cost of production are likely to witness a downward trend in milk prices over time (see **11.1.1.5**). The analysis suggested an interaction between trust and sanctions (see further below, **11.1.2**). For example, the *process of price determination* enhanced conditions of trust within value chains for liquid milk (**10.1**), with cost of production pricing providing both confidence in the continuity or predictability of the milk price, as well as influencing farmers’ mindsets regarding the fairness of such pricing (i.e. as the pricing was transparent and by reference to a formula). It seems likely that farmers’ views on the ‘fairness’ of such pricing mechanisms were influenced by the degree of price variation within the market, and by the fact that the prices paid under cost of production contracts were considerably higher than either spot market prices or non-

aligned prices. It is conceivable that – if prices paid under aligned contracts were to fall relative to non-aligned prices, this might alter farmers’ perspectives of cost of production pricing and potentially reduce levels of trust within aligned value chains.

11.1.1.12 Trust within Value Chains: Policy Implications

Policymakers might question whether creating an ‘elite’ group of farmers is consistent with the development and maintenance of a diverse, resilient and inclusive dairy farming sector. As outlined already (11.1.1.3), given that the research and extension activities of supermarkets are driven by their best-performing farms, and that these activities influence indirectly the entire sector, this raises the question of whether many voices are being marginalised, as the ‘problems’ of technological search and selection within the dairy sector are increasingly being framed by a diminishing group of increasingly large farms. Policymakers may therefore consider measures to support smaller or marginalised groups including, for example, those engaged in niche activities such as those outlined in 11.1.1.7 – 11.1.1.9.

As outlined already (11.1.1.6), policymakers might also consider, when developing legislation to implement compulsory contracts, whether the constant downward trend of cost of production pricing represents a ‘fair’ outcome for farmers over the long term, in particular given the considerable information asymmetries inherent in this method of price determination.

11.1.2 Contributions to Theory

This study combined three different theoretical lenses (4.1) in order to provide a richer understanding of the dairy sector, revealing and explaining trends within the sector and outlining future outcomes implied by these trends (11.1.1).

A ‘quasi-evolutionary’ model of technological change was developed through enriching an evolutionary perspective with elements drawn from the literatures on the social construction of technology (SCOT) and global value chains (GVC). As distinct from a ‘coupled’ or ‘circular’ model of technological change, this model provided a means of differentiating “more from less important links and interdependencies” in order to “indicate the main drivers of stability and change” (Millstone 2010, p.294).

The framework revealed considerable variety in technological decision making at the sub-sector level, building upon Leiponen and Drejer’s assertion that “industries are not at all uniform in terms of how [the] firms [within them] innovate” (Leiponen and Drejer 2007 p.1221). Although

dairy farming may be considered, *broadly*, as a “supplier-dominated” sector (Pavitt 1984), the degree of sensitivity of individual farms to downstream buyers – and the resulting impact upon technological change – may vary considerably. The framework provided a detailed account of the variations in the ways that different types of farm systems responded to comparable buyer demands. For example, intensive and extensive systems directed their technological ‘search’ towards different goals (maximising output per cow/robot versus minimising inputs, respectively) and their responses to low/high prices differed accordingly (as did the sequence of these responses).

In synthesising three different theoretical lenses, the study provided a contribution to the different bodies of theory being combined, often through the ways in which conceptual elements drawn from each of these bodies of theory supported or illuminated one another:

- For example, within the evolutionary tradition, much emphasis has been placed upon examples of conflict and contestation within *transitions* contexts (where the locus of conflict is typically at the intersection of niches and regimes, see 3.4.1). However, this study suggests that this may be at the expense of acknowledging the extent to which *reproduction* is a contested process. Incorporating concepts from SCOT and GVC provides a richer depiction of processes of conflict (and opportunities for change) that exist within system reproduction.
- Although patterns of technological change in the sector were often shown to be the product of collective stabilisation and closure of technological frames (i.e. a concept drawn from the SCOT literature), analytical/conceptual tools (‘sanctions’ and ‘trust’) drawn from the GVC literature provided a means of illuminating the different conditions under which, and mechanisms through which, such stabilisation and closure occurred (see 10.1). Therefore, in addition to highlighting the ways in which these different dimensions of value chain governance interact and support one another, the analysis also demonstrated that strong sanctions and high levels of trust – typical of aligned chains – supported a process of *collective* frame stabilisation. Notably, the presence of high, stable prices and the corresponding power to exclude (sanctions), in combination with the practice of collaboration and benchmarking (trust), influenced farmers’ mindsets regarding (or how they ‘framed’) the benefits of competition (depending upon whether they were inside or outside of aligned producer pools).
- A SCOT perspective encourages a view of ‘technological frames’ (3.4.1) as deriving from ‘meanings’ attached to artefacts. Such meanings correspond broadly to ‘cognitive

and normative rules' (see **Table 3a, 3.4.1**). GVC, by contrast, is principally concerned with 'regulative' rules. Therefore, by using a GVC perspective in combination with a SCOT perspective, the framework enriches the resulting analysis by illuminating the interplay of regulative, cognitive and normative rulesets.

Further, conceptual elements drawn from the SCOT literature supported and illuminated concepts drawn from GVC. GVC, being largely focused on regulative rules, potentially underplays the interaction between these rules and cognitive and normative rules. For example, whereas GVC regards 'trust' as a proxy for 'legitimacy', a SCOT approach encourages the analyst to view issues of legitimacy more critically, notably from the perspective of different groups of actors. Doing so reveals, for example, that aligned farmers viewed cost of production pricing as 'fair' (despite the fact that cost of production pricing entrenched considerable information asymmetries between buyers and farmers and, within benchmarked pools, resulted in a progressive reduction in the milk price received by the farmer; see above, **11.1.1.5**). Non-aligned farmers, by contrast were more wary of the risks associated with passing details of their production costs to buyers. Significantly, it is likely that aligned farmers' views on the fairness of cost of production pricing were influenced by the fact that they were receiving the highest, most stable prices (again, illustrating the importance of viewing regulative rules from the perspective of different actor groups).

Therefore, one critique of GVC, highlighted by its synthesis with SCOT within this study, concerns the question of whether the trust concept (including the positive connotations invoked by that word) permits a thorough examination of the issue of power imbalances and exploitation within relationships between chain participants. Notably, relationships may be long (i.e. an indicator of trust) merely due to the lack of alternatives. Moreover, farmers may regard their contract as being good *relative* to other (i.e. even worse) contracts available in the market, but this is not to say that the relationship between farmer and buyer is 'fair' (indeed, aligned farmers readily accepted the massive information asymmetries inherent in COP pricing, ostensibly because they were receiving a better milk price than non-aligned farmers). Finally, conditions of 'high trust' in practice meant that only those farmers at the top of benchmarked pools were able to exert influence over the direction of development of the farms within the pool (**11.1.1.10**).

11.2 Reflections on Methodology

The study's findings and contributions to knowledge should be considered in the light of the following limitations and qualifications.

Limitations of the scope of the research and research question – The study aimed to determine the influence of powerful buyers upon dairy farms. Given the complexity of markets for dairy products (see **Chapter 5**), it was desirable to limit the study to an analysis of the domestic liquid milk market, in order to more clearly detect the ‘signal’ of supermarket influence from the background ‘noise’ of, for example, movements in global commodity prices. Moreover, although many supermarkets operated dedicated, aligned pools for the procurement of liquid milk, they did not for the procurement of cheese and other dairy products. Restricting the study to a comparison between aligned and non-aligned liquid value chains therefore provided a more strategic focus for the research, enabling a clearer examination of supermarket power through the aligned/ non-aligned axis.

This was, in practice, a problematic distinction. Farmers can move fluidly between value chains for liquid milk and manufacturing (i.e. cheese). Indeed, two of those interviewed had undertaken such moves and another was in search of a cheese contract. Moreover, because processors operate across different value chains (i.e. liquid milk, cheese, etc) this was inevitably reflected both in their approach to ‘balancing’ and in the demands that they made of the farms supplying them through liquid contracts (in terms of, for example, constituent content). Several non-aligned farms reported that the production of protein and butterfat was increasingly rewarded within *liquid* contracts, ostensibly because these could be directed towards the production of other products (e.g. cheese, powders, etc). It was, therefore, not possible to consider liquid value chains completely in isolation from other value chains.

Limitations of analytical framework – Any analytical framework, by necessity, represents a simplification of reality (**3.3.2, Chapter 4, 5.1**). The intention is that a simplified representation of a complex system may offer insights into the operation of that system, and illuminate the key interactions within it. Nevertheless, it is important to acknowledge that, because certain interactions were accorded priority status within the analysis, other (potentially significant) interactions may have been underemphasised.

For example, because the framework emphasised the interaction between buyers’ demands and farms’ technological configurations, the potential significance of such variables as farmers’ financial position (**Farmer M; 7.2**), their access to credit and their succession plans, or the tenure status and ownership structure of farms, was not a key consideration. Given that the findings supported Leiponen and Drejer’s claims regarding sub-sector level heterogeneity – an insight drawn from the ‘strategic management’ literature – issues such as ownership structure might be factors to consider within future research examining such heterogeneity.

The analytical framework could be adapted to incorporate additional financial, labour or environmental variables for the purposes of future research (see below **11.3**).

A key limitation of the framework, and of its application, was that the influence of actors upstream from farmers (e.g. developers, producers and suppliers of technologies) and, in particular, downstream from buyers (i.e. end consumers) was given insufficient attention. Although it demonstrated the direct and indirect influence of supermarkets upon farmers, the study did not explore fully the extent to which supermarkets were themselves driven by consumer demands (e.g. for transparency, 'fair pricing' or animal welfare), or the degree to which the continued operation of aligned value chains relied upon their 'PR' value to supermarkets. Such factors may provide a further insight into the future direction and sustainability of aligned value chains. The framework may be adapted to incorporate a more complete analysis of upstream and downstream actors for future studies.

Limitations of data and data analysis – Access to the Milkbench+ dataset was restricted to a limited number of data fields which did not include, for example, complete data regarding farm accounts (as outlined in the point above, because the analysis was centred on the interaction between buyer demands and farms' technological configurations, the data fields requested from AHDB were those relating most closely to technologies). Moreover, interviews with farmers were limited to an hour and therefore concentrated on those areas of most immediate relevance to the analysis.

'Clusters' of farms corresponding to a novel typology of different system types (intensive, intermediate, extensive) were extracted from an abridged version of AHDB's "Milkbench+" dataset – which covered the period 2007-2013 – using principal component analysis and cluster analysis of cross sectional data for the year 2013. The shortcomings of the data include the inability to capture potential annual fluctuations in input variables such as rainfall, which might vary by region and might affect different system types to varying degrees, influencing the use of both housing and feeding technologies. Anomalies in such conditions may have affected the clusters to which farms were allocated.

Basing the clusters on data averaged over the entire 2007-2013 period, rather than on the data for a single year (2013), might have smoothed the volatility caused by weather conditions or short term movements in market prices for feed inputs. However, using 2007-2013 averages would have resulted in a much smaller sample size as only 15 farms submitted data returns for

every year. Moreover, this approach would have been complicated by the fact that data for some variables had been retrospectively overwritten from one year to the next.

Notwithstanding the above limitations, the analysis of the Milkbench+ dataset was adequate for the purpose of producing approximate clusters from which to shortlist farms for more in depth interviews.

More broadly, identifying ‘boundaries’ between clusters was difficult (see **Chapters 6 and 9**). Although the distinctions between intensive and extensive farms were clear, distinguishing intermediate farms from both extensive and intensive farms presented a greater challenge, because farm systems are typically differentiated from each other by reference to scale variables rather than categorical variables, with the result that boundaries between clusters appeared indistinct or arbitrary. For example, while the cluster analysis had allocated **Farm H** to the ‘intermediate’ cluster, interview data appeared to place it on the boundary between intermediate and extensive systems. This may be either because of the limitations of cluster analysis (outlined above), or because of changes that had taken place on the farm in the intervening period between the 2013 and the date of the interview (2016).

A key limitation of the study was the absence of interview data collected from farmers who had exited the sector due, for example, to persistent conditions of low milk prices. Such interviews would have provided a means of validating some of the trends identified in the analysis, such as the suggestion that high, stable prices were essential for the functioning of intensive and intermediate farms. Moreover, the study did not include any farmers that were operating towards the ‘bottom’ of aligned pools in terms of efficiency (i.e. for whom exclusion from the pool therefore presented a more imminent threat, and who might have offered a different view regarding the ‘fairness’ of cost of production pricing), or farmers that had been excluded from such pools. Such farmers might have offered useful additional evidence of the pressures associated with benchmarking, and possibly a different account of the conditions of trust within these value chains.

Finally, when deploying the concept of ‘technological frames’, farmers’ frames were inferred from interview data, whereas buyers’ frames had to be inferred from contract data, milk prices and farmers’ accounts of buyer-farmer relations. Interviews with buyers would have enriched the depiction of buyer frames.

11.3 Further research

The contributions and limitations outlined above highlight several important areas for future research, not only within the UK value chain for liquid milk, but within global value chains for dairy and other agricultural products, and, more broadly, within sectors that exhibit similar characteristics to the UK dairy sector.

For example, the approach taken within this study, its findings, and the areas for further research highlighted by these, may be applicable to the study of value chains in which a large number of producers supply a small number of powerful buyers with a homogeneous, commoditised product, and in which “it is supermarkets which are the most powerful actors” (Mylan et al 2015, p.20). This includes value chains for food commodities, for example, horticultural products (Gereffi et al 2005) such as fruit and vegetables (Vagneron et al 2009; Dolan and Humphrey 2000) or coffee (Kaplinsky and Fitter 2004). The findings may equally apply to value chains for products such as cut flowers, which are also characterised by “the rising power of UK retailers” which may “exert control over supply chains” (Hughes 2000, p.175).

Notably, some previous studies of such value chains have suggested that “retailers often put pressure on suppliers to reduce costs, which may lead to antagonistic and distrustful relations” (Mylan et al 2015, p.21). This stands in contrast to this study’s findings, namely that relations between supermarkets and the dairy farms that supplied them directly were characterised by higher conditions of trust relative to non-aligned value chains, partly as a result of price variation in the wider market and partly as the result of longer, more collaborative relationships identified in these chains. This implies that the governance of the UK dairy value chain may bear some unique characteristics (e.g. cost of production pricing, benchmarking etc), which may be compared and contrasted against the governance of other supermarket value chains (e.g. value chains for products such as beef – Mylan et al 2015 – in which supermarkets often operate dedicated supplier pools, or value chains for fresh fruit and vegetables, in which they do not).

Such work may enrich the findings of, for example, Mylan et al, who identified that the “co-ordination” of eco-innovation efforts by supermarkets varies between different supply chains, with supermarkets being more active in dairy supply chains than in value chains for beef or bread (ibid.). It may equally provide new avenues of research within the study of ‘own label products’ in the fresh produce sector (Fearne and Hughes 1999) or, more broadly, within the study of ‘private standards’ as a “mode of market governance” in other global value chains (Henson and Humphrey 2008; Kaplinsky 2010).

Looking beyond the agricultural sector, the findings (and areas for further research that they illuminate) may apply to the study of sectors such as the apparel / garments and textiles, which have been studied extensively within the GVC literature (Gereffi et al 2005), while applying the framework developed within this study (with its synthesis of concepts drawn from the GVC literature and those from an evolutionary / SCOT perspectives) may offer a contribution towards illuminating the insights that a GVC perspective may bring to “understanding trajectories” (Schmitz 2007, p.152).

Specifically, areas for future research within the UK value chain for milk (which may also be applied more broadly to the value chains outlined above), include:

- The impact of price variation upon innovation activities within markets for commoditised products, and the exploration of policy options to address such impacts.
- The influence of actors upstream from farms and downstream from buyers, and in particular the influence of end consumers upon the ‘closure and stabilisation’ of technological frames.

A focus upon the role of end consumers within the UK value chain for milk also highlights the necessity for further research into the potentially contradictory effects of aligned pools upon producers’ ability to capture returns. Broadly, producers of commodities capture a small share of the value from the sale of products due to “the relatively undifferentiated nature of final product markets” (Kaplinsky and Fitter 2004, p.7). On the one hand, consumer influence within the UK milk market may contribute towards a ‘de-commodification’ (Kaplinsky and Fitter 2004) of liquid milk (in the limited sense that the development of aligned supermarket pools – ostensibly in response to consumer demands for improved traceability, animal welfare standards, or the ‘fair’ treatment of farmers – may be regarded as introducing greater product differentiation into the liquid milk market). On the other hand, the homogenisation of production (see **Observation 4**) associated with aligned pools – and the diffusion across the wider sector of best practices developed in aligned pools – tends to militate against this, resulting in a less-differentiated production sector.

This raises the broader question of the impact of different degrees of product differentiation upon producers’ approaches towards technology adoption, which might be compared across diverse value chains characterised by varying degrees of product differentiation (e.g. milk versus coffee versus wine; Gwynne 2006).

- The interactions between supermarkets and processors and between larger and smaller processors, and in particular the conditions of trust within the wider value chain, given

that processors operate across both aligned and non-aligned value chains. Of particular interest are the margins captured by *processors*, given that processors operate across many of different value chains for milk (i.e. aligned liquid, non-aligned liquid and manufacturing). There is, further, the question of whether supermarket price wars (and/or supermarkets' practice of 'playing processors off against each other') have served to squeeze processors' margins, and whether processors consequently pass these losses on to farmers. Notably, such research may further illuminate the ways in which the power of processors varies between aligned and non-aligned value chains, and may reveal impacts of this upon farmers, such as, for example, the potential for processors to pass income reductions or losses associated with aligned contracts on to their non-aligned suppliers.

- The issue of reliance on both sides of the buyer-supplier relationship. One potential hypothesis for future testing is that consolidation within aligned producer pools increases buyers' reliance upon farmers, which may reduce the threat of exclusion and increase the co-operation between buyers and suppliers. One might also hypothesise that it would be against buyers' interests to promote excessive consolidation (and the expansion of individual producers) within supplier pools, as ultimately this trend may increase buyers' reliance upon farmers.
- The potential relationship between the diminishing size of producer pools and increasing levels of trust within them, given that the study found considerable preliminary evidence to suggest that *smaller* supermarkets are more reliant upon individual farmers compared with other milk buyers.
- The possibility that reliance and duration of relationships results in investment effects as the operation of supplier pools – including benchmarking and the resulting provision of research and extension services – represents an investment on the part of supermarkets. Such investment may increase in proportion with increases in the duration of relationships and levels of reliance. This provides a possible hypothesis for future testing.
- Whether the tendency towards consolidation within aligned pools over time serves to intensify expectation and co-ordination effects amongst the remaining farmers within these pools, increasing the rate of farmers' progress towards goals and/or further inhibiting future changes in direction.

- The indirect influence of supermarkets upon farmers that do not currently supply them, notably through research and extension activities. Such research may centre on policy questions including: who is driving the technological research agenda within the UK dairy sector? Who 'frames' the 'problems' of technological search and how and by whom are the approaches to solving these problems selected? Are some voices marginalised within this process of negotiation (see **11.1.1**, above)?

It is hoped that the approach taken within this study, and its findings, will help to illuminate future research into these areas and beyond.

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APPENDIX 5A: Key Differences Between Varieties Of Concentrate Feeds

Feed category	Sub-category 1	Sub-category 2	Key nutritional characteristics					
			Energy density (MJ / KgDM)	Composition (e.g. starch / sugar / fibre)	Consistency of composition	Form of feed		
Concentrates	Straights (home grown)	Wheat	Cereals and pulses are useful suppliers of energy.	Starchy energy from cereals can have beneficial impact on milk protein. Readily fermentable energy in wheat, in particular, means risk of acidosis with high inclusions. Good source of protein.	Variable. Allows for flexibility to fine tune rations, but requires ration formulation skill. Different ingredients with similar names can have very different nutrient values. Quality and analyses can vary between loads.	Unpelleted. Care needs to be taken with inclusion rates, especially where the grains are finely ground		
		Barley						
		Oats						
		Peas						
		Beans						
		Triticale						
	Straights (purchased)	Various by-products of food or industrial processes		Over-processing and contamination can interfere with nutritive value			Relatively consistent, saving on farm mixing and ration formulation complexity. However, different sources can differ widely in sophistication of blending. Mixing can be variable. Ingredients can separate out during storage and handling. Some degree of farm ration formulation skill is likely to be required.	Unpelleted
		Blends		Quality and analyses can vary between loads. Minerals and vitamins may or may not be included.				
	Compounds			Consistent; generally well-balanced and mineralized. No farm mixing or ration formulation required. However, the only flexibility offered to adjust rationing is by the amount fed	Pelleted			

Source: Adapted from: <http://dairy.ahdb.org.uk/technical-information/feeding/concentrate-feeds/>
#.VrhpxGrbzI

APPENDIX 5B: Main UK Dairy Breeds: Key Average Production Characteristics

	BREED							
	Ayrshire	Brown Swiss	Friesian (British)	Guernsey	Holstein	Jersey	Montbeliarde	Shorthorn
Yield (kg)*	6,640	7,431	6,727	5,834	8,432	5,744	6,820	6,079
Fat %*	4.03	4.02	4.05	4.77	3.88	5.21	3.80	3.77
Protein %*	3.30	3.36	3.29	3.54	3.18	3.80	3.34	3.26
Somatic cell count ('000 cells / ml)*	175	168	185	218	206	185	183	176
Calving interval (days)*	418	413	411	421	428	411	397	397

* 2009/10 figures, source: National Milk Records Annual Production Report 2010;
<https://www.nmr.co.uk/software/annual-production-report>

APPENDIX 5C: Main UK Dairy Breeds: General Characteristics

BREED	GENERAL CHARACTERISTICS
Ayrshire	<p>"Efficient Forage Conversion"</p> <p>"Excellent Functional Type"</p> <p>"Noted for strong udder formation"</p> <p>"Health and freedom of (sic) disease and ailments"</p> <p>"Characterised by high quality, longevity, ease of management and overall good health"</p> <p>"efficiently produce large quantities of high quality milk from forage... now becoming very popular in organic systems"</p> <p>Source: http://www.ayrshirescs.org</p>
Brown Swiss	<p>"strongly built animals [with] sound feet and leg structure and well-attached udders"</p> <p>"show more insect resistance and have dark skin pigmentation around their eyes, which lessens the occurrence of pink eye infections"</p> <p>"renowned for their natural grazing instinct and efficient conversion of forage and the relatively flat lactation curve gives rise to breed's reputation for having statistically fewer metabolic problems"</p> <p>"greater resistance to mastitis, less prone to milk fever, flatter lactations leading to less loss of condition after calving (with its positive effects on fertility) and the ability to average a couple of lactations more at the high milk yields"</p> <p>Source: http://www.brownswiss.org</p>
Friesian (British)	<p>"Lower maintenance costs due to feed efficiency of smaller frame cow"</p> <p>"Lower vet costs due to better fertility (lower AI costs), less lameness, less mastitis and greater resilience"</p> <p>"Lower replacement rate so more options to sell surplus stock"</p> <p>"Improved milk quality due to lower mastitis and higher butter fat and protein content."</p> <p>"the British Friesian has developed along slightly different lines and remains a dual-purpose animal with the potential to produce substantial volumes of milk and produce male calves that can be fattened up to produce quality beef."</p> <p>Sources: http://www.britishfriesian.co.uk/content/British_Friesian_Slide_Show.pdf +http://ukcows.com/holsteinUK/publicweb/Education/HUK_Edu_DairyCows.aspx?cmh=66</p>
Guernsey	<p>"The Guernsey... [is] most famous for the rich flavour of milk."</p> <p>"Guernseys are... being added to other breed herds to improve the overall quality of the milk supply"</p> <p>Source: http://www.guernseycattle.com/about/breed-facts/</p>
Holstein	<p>"In the UK and many countries across the world, the Holstein is the predominant breed because of its ability to produce high volumes of milk efficiently."</p> <p>Source: http://ukcows.com/holsteinUK/publicweb/Education/HUK_Edu_DairyCows.aspx?cmh=66</p>
Jersey	<p>"Relatively small in size - about 400 to 450kgs... Despite her small size the Jersey is renowned for its ease of calving, allowing it to be crossed with the larger beef breeds"</p> <p>"Renowned for the quality of... milk... In the UK milk and dairy products from both Jersey and Guernsey cows are increasingly being sold under the "GOLD TOP" label, which is reserved for sole use. Jersey milk has always been associated with luxury"</p> <p>"Jerseys thrive under both extremes of temperature - they can grow thick coats in very cold climates, whilst suffering from much less heat stress than the other dairy breeds in hotter regions of the world. Jerseys perform well under a wide range of systems"</p> <p>"Studies... show the Jersey to be less prone to many diseases than the other dairy breeds"</p> <p>Source: http://www.ukjerseys.com/breed/facts.html</p>
Montbeliarde	<p>"the Montbeliarde is known as the cheese maker breed in France because of the high protein levels."</p> <p>"the Montbeliarde has... on average a 50,000 lower cell count compared with the Holstein for a similar level of milk production."</p> <p>"The cows hold a better body condition in lactation which has a positive effect on fertility and health."</p> <p>"The Montbeliarde is a long lasting breed, 25% of Montbeliarde cows are in their 5th lactation or more."</p> <p>"There is a 20 day reduction in calving interval for the Montbeliarde compared with the Holstein in France. For first conception rates, the Montbeliarde is 10pts higher than the Holstein, 15pts higher on second lactation."</p> <p>"originating from a mountain region [Montbeliardes] have always been bred for strong legs and feet"</p> <p>"Beef value: Pure bred Montbeliarde bull calves can be £120 greater value than the Holstein equivalent"</p> <p>Source: http://www.montbeliardeuk.co.uk/information.html</p>
Norwegian Red	<p>"Keeping a balanced breeding goal for the last 40 years ... has overcome the negative correlation between production traits and health and fertility traits. This has resulted in a world-leading cow that has excellent production, health and fertility traits"</p> <p>"With good production capabilities and being known as the 'problem free cow', the Norwegian Red lasts longer on average than most modern dairy breeds"</p> <p>Source: https://www.norwegianred.com/Start/Norwegian-Red/about-norwegian-red/Norwegian-Red-characteristics/</p>

BREED	GENERAL CHARACTERISTICS
Shorthorn	"Excellent mobility" "Excellent milk quality" "Excellent fertility and longevity" "Excellent converters of forage to milk" "Excellent temperament and adaptability" "Suitable for all types of production systems, particularly extended grazing and organic systems." Source: http://www.shorthorn.co.uk/dairyshorthorn/index.php/the-breed/history-of-the-breed

NB: These descriptions have been extracted from materials produced by the breeding societies associated with each breed and therefore may be susceptible to bias. It should be borne in mind that the characteristics attributed to each breed are, to some extent, the basis upon which the breed is being marketed.

APPENDIX 6A: Comparisons between the Milkbench+ Dataset and the Wider Population

In 2013, there were 14,276¹ dairy farms in the UK. The Milkbench+ dataset for year ending 2013 contained 421 farms. This sample size offers a margin of error of +/- 4.71% (+/- 6.19%) at a 95% (99%) level of confidence.²

The following tables present the geographical distribution of farms in Milkbench+ dataset, by country and region, compared with the actual distribution of UK dairy farms:

		Distribution of Farms in Milkbench+ Dataset		Actual distribution of dairy farms in 2013 ³	
		Frequency	%	Frequency	%
Valid	England	325	77.2	8,587	60.15
	Scotland	48	11.4	n/a	n/a
	Wales	48	11.4	1,874	13.13
	Northern Ireland	0	0	n/a	n/a

	Distribution of Farms in Milkbench+ Dataset (%)	Actual distribution of dairy farms in 2013 (%) ⁴
Unknown	1.4	n/a
East Midlands	4.3	5.6
East of England	4.5	1.2
Glasgow	.5	n/a
Lothian	.2	n/a
Mid and West Wales	4.8	10.9
Mid Scotland and Fife	.7	n/a
North East England	1.2	6.0
North East Scotland	.7	n/a
North Wales	5.2	4.2
North West England	11.2	18.2
South East England	8.6	3.9
South Scotland	8.6	n/a
South Wales East	.7	n/a
South West England	30.6	27.8
West Midlands	8.1	11.4
West Scotland	.7	n/a
Yorkshire and the Humber	8.1	1.6

¹ <http://dairy.ahdb.org.uk/resources-library/market-information/farming-data/producer-numbers/#.XB9AVRQR75o>

² <http://www.surveysystem.com/sscalc.htm>

³ <http://dairy.ahdb.org.uk/market-information/farming-data/producer-numbers/uk-producer-numbers/#.ViXrzutM7ww>

⁴ *ibid.*

The Milkbench+ dataset appeared strongly representative of the broader population of dairy farms in terms of yields per cow. Average yield per cow in the UK in 2013 was 7,535 litres / cow / annum⁵. For the Milkbench+ dataset the mean yield per cow was 7,338.73 and the median yield 7,474.73 per annum. The distribution of production approaches of farms within the Milkbench+ dataset also mirrored the findings of other, larger datasets. For example, a 2014 survey of over 3,000 UK dairy farms revealed that 78% of farms were calving all year round, 7% were Autumn calving, 11% were Autumn / Spring calving, and 4% were Spring calving.⁶ The Milkbench+ sample by comparison contained 76.72% all year calved herds, 7.84% Autumn calved, 7.84% multi-block, and 7.7% Spring calved.

⁵ DairyCo 2013 "Dairy Statistics: an insider's guide 2014" p.18

⁶ <http://www.nfru.co.uk/research/newsletter-nov2014.html>

APPENDIX 6B: Data Obtained from Milkbench+ Dataset, Related to System Components

SOCIO-TECHNICAL SYSTEM INPUTS AND OUTPUTS	VARIABLES SELECTED FROM MILKBENCH+ DATASET
RESOURCES	
Physical	Region ('Unknown', East Midlands, East of England, Glasgow, Lothian, Mid and West Wales, Mid Scotland and Fife, North East England, North East Scotland, North Wales, North West England, South East England, South Scotland, South Wales Central, South Wales East, South Wales West, South West England, West Midlands, West Scotland, Yorkshire and the Humber) Country (England, Scotland, Wales) If you the farm is in an NVZ (nitrate vulnerable zone), what percentage of the farm area is covered by the restrictions?
Financial	Imputed depreciation on dairy machinery and equipment Total Dairy Fixed Costs (£) Fixed Costs per Cow (£) Total Dairy Variable Costs (£) Variable Costs per Cow (£) Total machinery and power costs allocated to the dairy enterprise (£) Machinery and power costs allocated to the dairy enterprise per cow (£)
Labour	Labour hours per cow
TECHNOLOGIES	
Feeding technologies	Do you feed a TMR? Average metabolisable energy (ME) in feed ration (MJ per kgDM) Average metabolisable energy (ME) in forage ration (MJ per kgDM) Total feed in DM weight (KgDM) Feed per Cow in DM weight (KgDM) Total forage in DM weight (KgDM) Forage per cow in DM weight (KgDM) Total byproducts fed in DM weight (KgDM) Byproducts fed per cow in DM weight (KgDM) Total compound feeds fed in DM weight (KgDM) Compound feeds per cow in DM weight (KgDM) Total cereals fed in DM weight (KgDM)
	Cereals fed per cow in DM weight (KgDM) Number of full dairy grazing weeks Total non-grass forage crops (adjusted for DM) Non-grass forage crops per cow(adjusted for DM) Total proteins fed in DM weight (KgDM) proteins fed per cow DM weight (KgDM) Total grass silage fed in DM weight (KgDM) Grass silage fed per cow in DM weight (KgDM)
Buildings and Housing technologies	Housing Type (cubicles, Loose Housing, None) Housing Period in Weeks
Breeding and Fertility technologies	Cow Breed (Ayrshire, Channel, Crossbred, Friesian, Holstein, other) AI (artificial insemination) and breeding costs for the dairy herd (£) AI (artificial insemination) and breeding costs per cow (£)

Milking technologies	Type of Milking Parlour (herringbone, rotary, robots, other)
	Number of milkings per day
	How many milking points does your parlour have?
Animal husbandry and veterinary medicine technologies	Bactoscan (in thousands)
	Average number of dairy cows
	Dairy stocking rate (LU / ha)
	Veterinary and medicine costs for the dairy herd (£)
	Veterinary and medicine costs per cow (£)
	Number of Dairy Cows Culled per year
Production cycle ('calving pattern') technologies	Calving Pattern (All Year, Spring, Autumn, Multiblock)
INSTITUTIONS	Farming System (Conventional, Organic)
	Type of Contract (Liquid, Cheese, Other)
	Type of Contract (aligned, Non-aligned)
	Average Milk Price (£)
OUTPUTS / PRODUCT CHARACTERISTICS	
	Yield per cow (litres / year)
	Butterfat percentage in milk
	Protein percentage in milk
	Somatic Cell Count (SCC) in milk (in thousands)

APPENDIX 6C: Briefing Materials Provided to Interviewees



Information sheet for interviewees for the project ‘Understanding patterns of innovation within the UK milk production sector’

You are being invited to take part in a research study on technological change in the UK dairy sector. Taking part in this research is entirely voluntary – if you do decide to do so you will be given this information sheet to keep and will be asked to sign a consent form. However, you are still free to withdraw at any time and without giving a reason. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please read the following information carefully.

This project is being undertaken by James Thomas, a Doctoral Researcher in the Science Policy Research Unit (SPRU) at the University of Sussex. James is being supervised by Professor Erik Millstone, Professor in Science Policy at SPRU, and Dr Adrian Ely, Senior Lecturer at SPRU. This project aims to understand the factors influencing the adoption and retention of technologies by UK dairy farmers.

The fieldwork will comprise interviews with dairy farmers in the UK. You have been invited to participate as such an individual. In the interview James will ask you a series of questions regarding:

- The current production system used on your farm
- The ways in which the different technologies you use interact, and
- Changes in your production system, and how you arrived at your current production system

We anticipate this will take around 1 hour and ideally would like to audio-record the interview so that answers can be captured accurately. There are no costs to taking part other than your time.

All information collected about individuals will be kept strictly confidential (subject to legal limitations), and we will not collect sensitive personal information (e.g. ethnicity, political views, sexual orientation, beliefs etc). Original recordings of the interviews will be kept on a secure, password-protected computer and will be destroyed after the project has finished. During the project, transcriptions of the interview will be stored separately and identified by a unique identifier code. If any direct quotes are used in the final project report or any project publications, these will be identified in accordance with your wishes (see consent form). If anonymity is desired, quotes will be identified through a descriptor (e.g. “Farmer A”). We will send you direct quotes with some surrounding text for you to approve prior to publication.

The results of this research will be published as a PhD Thesis, a copy of which will be stored at the University of Sussex and made available to students of the University. It is also possible that the thesis may be cited or reproduced within academic publications. All forms of published output will be made available to project participants.

Please feel free to contact James Thomas if you have any questions or need further information at any point: Tel: 01273 812398, email: jt267@sussex.ac.uk. If you have any concerns about the way in which the study has been conducted, you should contact: Romy Hasan, School Research Ethics Officer, email: R.Hasan@sussex.ac.uk, Tel: 01273 876582

Thank you for taking the time to read this information sheet and we look forward to answering any questions you have.

APPENDIX 6D: Questions Included within Semi-structured Interviews

Questions in **red** are for aligned farms only, questions in **blue** are for non-aligned farms only, questions in **black** apply to all farms.

1. **The NFU describes three main production systems used in the UK as: 'extensively grazed', 'grass-based' or 'zero-grazed'. Is this a useful way of categorising different farming systems? If so, which category would you say your farm falls into?**

NB: If necessary, prompt farmers to cover the following specific areas:

- Total feed per cow (DM)
- Ratio of forages to concentrates
- Proportion of concentrates comprised of compound feeds
- housing period
- stocking rate
- number of cows
- breed
- calving pattern and interval
- yield per cow
- constituents
- SCC (less important)
- Bactoscan (less important)

2. **Can you explain why you use this farming system, as opposed to any other?**
3. **How has your system changed since 1994?** Again, prompt farmers to cover the specific areas (feed per cow etc)
4. **Can you explain when and why these changes have taken place?** What prompted the changes you have described in your farming system? What guided your decisions? What role has the market played in this?
5. **Can you explain to me any major investments in technologies that you have made on the farm (e.g. milking parlours, buildings and housing) since 1994?** How and when did you make these? Have these investments been related to the changes you have described in your farming system? How? Is there a particular order or sequence in which you have had to make these changes?
6. **How would you describe your strategy with regards to your production system and long-term investment in technology?**
7. **What aspects of the farm do you outsource? Why? And how long have you been doing this?**

8. **When were you awarded your supermarket contract?**
9. **Aligned contracts are in strong demand. To what do you attribute your ability to secure one?**
10. **What did your production system look like at the time that you were awarded the contract?** I may want to get an idea of this both in an objective sense (i.e. What were your inputs and outputs relative to today's levels?) but also in a more subjective sense (i.e. At the time of the award do you feel you were 'ahead of the game?' relative to your peer group?)
11. **Did winning the supermarket contract result in a change to your approach? Has supplying a supermarket required you to change your farming approach in any way? Would you be farming the way you are now if you weren't supplying a supermarket?** (Plus an appropriate follow up question depending on their response).
12. **Is there much knowledge sharing within your pool of farmers? Can you give me examples of this?**
13. **Would you be willing to show me a copy of your current contract, and previous contracts?**
14. **Has your contract required you to change your farming approach in any way?**
15. **Putting the contract to one side, has your broader relationship with your milk buyer required you to change the way you farm?**
16. **Is there much knowledge sharing within the pool of farmers supplying your milk buyer? Can you give me examples of this?**
17. **Although you do not currently supply a supermarket, would you be interested in an aligned supermarket contract? Why / why not?**
18. **What do you think supermarkets are looking for in the farms that supply them?** [What do other farmers on aligned contracts look like?]
19. **Would you be willing to show me a copy of your current contract, and previous contracts?**
20. **What is the single most important technology to you, as a dairy farmer? Why?** (NB: reiterate my broad definition of "technology")
21. **Are there any technologies that have revolutionised the way you produce milk?**

22. Are there any technologies used on the farm that require you to use other technologies with them (e.g. feeding systems that only work with proprietary pelleted feeds)?
23. Are there any technologies used on the farm that prevent you from using other technologies?
24. Have the changes in your farming system that you have already described required you to implement any new technologies? If so, is there any particular order or sequence in which you have had to implement these?
25. Do you feel that the changes in your farming system that you have already described have been helped by, or hindered by, technology?
26. Is there anything about your current farming system that prevents you from moving towards a different farming system?
27. If you wanted to move from your current farming system towards another farming system, what would be the biggest technological changes that this would require? What would be the first thing you would have to change on the farm?

APPENDIX 7A: Farm I Timeline

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Technological change (inputs)																							
Feeding		Limited grazing, maize silage, blend and concentrate										No grazing maize silage, blend and concentrate											
																						Zero grazing	
Buildings and housing			Straw yards	Sand cubicles								New cubicle shed, permanent housing											
Breeding			Holsteins, genetically selected for yield									Holsteins, selected for longevity and teat placement											
Milking			10 / 20 Herringbone milking twice daily									2 robots milking 2.6 times daily											
Fertility												Activity collars introduced											
Production cycle (calving pattern)			Year round calving																				
Herd size / stocking rate			120-150 cows																				
Technological change (outputs)																							
Yield per cow			8,000 litres per cow									10,000 litres per cow											
SCC / Bactoscan			Mastitis 60 cases per 100 cows									Mastitis 15-20 cases per 100 cows											
Change in buyer demands																							
New buyer			First Milk																Cotteswold				
Security of supply																			Seasonality payment scheme including "payment holidays". Has changed from "white water" to payment for constituents.				

APPENDIX 7B: Farm M Timeline

c.9,200

APPENDIX 7D: Farm O Timeline

[illegible]

APPENDIX 7F: Freshways A/B Pricing

SCHEDULE 2-DETERMINATION OF THE VALUE OF STANDARD LITRES

The calculation of Standard Litres Volume and Non standard Litres Volume will be calculated as follows:

- 1) The standard litres weekly volume will be 48,000 litres per week up until the end of March 2016. In subsequent years it will be calculated based on an average of the previous 2 years supply or as otherwise agreed between FRESHWAYS and the THE PRODUCER.
- 2) For the monthly period of supply, the Standard litres volume will be calculated by multiplying the standard litres weekly volume by the number of weeks in the relevant monthly period.
- 3) FRESHWAYS will adjust the standard litre volume for each period to take into account collection patterns in such a way as to NOT disadvantage either party.
- 4) A tolerance will be permitted based on +X % or – Y%. If the actual Litres supplied falls between the + or – minus range, then those litres will be deemed as the STANDARD LITRES supplied.
- 5) X referred to in 3 above will be 5 as from the commencement date of this agreement. FRESHWAYS is permitted to reduce X to a minimum of 2 by giving 3 months notice to the THE PRODUCER.
- 6) Y referred to in 3 above will be 5 as from the commencement date of this agreement. FRESHWAYS is permitted to reduce Y to a minimum of 2 by giving 3 months notice to the THE PRODUCER.
- 7) NON STANDARD LITRES are Volumes over or below the agreed/determined Standard litres as indicated in 3 above.

For the avoidance of Doubt and as an example:

- 1) If the weekly litres are agreed as 10,000 litres
- 2) and there are 4 weeks in the relevant period,

Then;

The THE PRODUCER can supply between 38,000 (-5%) and 42,000 (+5%) litres of milk. All volume within this range will be classed as STANDARD LITRES.

All volume outside of this range (above or below) will be classed as Non Standard Litres

SCHEDULE 4- CALCULATION OF THE PRICE FOR NON STANDARD LITRES

- 1) In each monthly period of supply, an “open market Price (OMP)” will be determined in accordance with clause 4 below

- 2) If in any month period the OMP is **BELOW** the Standard Litre Price Payable:

If the actual Litres supplied are **below** the contracted Monthly Period Standard Litres, there will be no deduction.

If the actual Litres supplied are **above** the contracted Monthly Period Standard Litres, then a deduction for the Non Standard Litres supplied will be made by multiplying the number of Non Standard Litres by the difference in the Standard Litre price and the OMP.

By way of example:

If the standard litre price is 50p per litre and the OMP is agreed as being 40p.

If a Producer supplies less than his standard litres, NO deduction

If a producer supplies 10,000 litres above his standard litres, then there will be a charge of £1000-00 (10,000 litres multiplied by 10p)

- 3) If in any month the OMP is **ABOVE** the standard Litre Price Payable:

If the actual Litres supplied are **below** the contracted Monthly Period Standard Litres, there will be a deduction made by multiplying the Number of Non standard Litres by the difference in the Standard Litre price and the OMP

If the actual Litres supplied are **above** the contracted Monthly Period Standard Litres, then an additional payment will be calculated by multiplying the number all Non standard Litres by the difference in the Standard Litre price and the OMP

By way of example:

If the standard litre price is 50p per litre and the OMP is agreed as being 60p.

If a Producer supplies less than his standard litres, then there will be a charge of £1000-00 (10,000 litres multiplied by 10p)

If a producer supplies 10,000 litres above his standard litres, then those 10,000 litres will be paid for at the rate of 60p (an additional 10p above the standard litre price)

- 4) The OMP will be determined by FRESHWAYS based on a like for like basis and is the price at which milk has had to be sold by FRESHWAYS or Purchased by FRESHWAYS during the supplying monthly period. FRESHWAYS must make available to Stephen Bradley sufficient audited information to justify the OMP.
- 5) THE PRODUCER may if he chooses, appoint an independent auditor to review the information used to determine the OMP. The cost of this to be paid directly by THE PRODUCER.

APPENDIX 7G: Tesco Core Milk Volume Allocation



**Milk &
Ingredients**

[Redacted]

Müller Milk & Ingredients
Western Way
Market Drayton
Shropshire
TF9 3UJ
www.muller.co.uk

Tel: +44 (0) 1630 650200
Fax: +44 (0) 1630 658427

20th April 2016

Dear [Redacted]

Tesco Sustainable Dairy Group (TSDG) Core Milk Volume Allocation 2016/17

From 1st March 2016 all Tesco milk will be supplied from the Tesco Core milk pool. To achieve this we need to have adequate supplies of milk throughout the year taking into account the trough milk production months and any spikes in Tesco demand. It is essential that we are able to meet 100% of Tesco orders throughout the year.

As a consequence there will be an element of scale back throughout the year with the actual allocation of Tesco litres dependent on the volume of milk produced by TSDG Members and the level of demand from Tesco for each individual month. In order to allocate the available Tesco litres we will use the average of your actual collected litres in the milk years 2014/15 and 2015/16 for each individual month to calculate your "Base Monthly Volume" for that month.

Where monthly demand > 70% of the sum of the "Base Monthly Volumes" for all Producers, then all Producers will initially receive an allocation equal to 70% of their "Base Monthly Volume" for that month. Any unallocated litres at the end of this process will be allocated proportionately across all TSDG Members based on their actual production in that month, not their "Base Monthly Volume".

Where Demand is < 70% of the sum of the "Base Monthly Volumes" for all Producers, all qualifying litres will be allocated proportionately across all Tesco Sustainable Dairy Group Members based on their "Base Monthly Volume".

Any litres produced that do not receive the Tesco milk price will be paid for at the Müller Milk & Ingredients Standard Price.

On the reverse of this letter, please find a table detailing your individual Base Monthly Volume for the milk year 2016/17.

Yours sincerely,

[Redacted Signature]

Müller UK & Ireland Group LLP
Registered Office
Tern Valley Business Park
Shrewsbury Road
Market Drayton
Shropshire, TF9 3SQ
Registered in England under
Partnership Number OC384928

APPENDIX 7H: Arla Seasonality Scheme

TABLE A
LIQUID MILK PRICING

Arla MILK PRICING - Liquid

1st January 2016 Forward - EXAMPLE

RAW MILK VALUE

BASE PRICE

8.403ppkg

BUTTERFAT ADJUSTMENT VALUES

For values 4.01% and above, plus 2.423p/1%

For values 3.71% - 4.00%, plus 1.961p/1%

For values 3.50% - 3.70%, plus 1.961p/1%

For values 3.49% and below, plus 1.47p/1%

PROTEIN ADJUSTMENT VALUES

For values 3.31% and above, plus 3.634p/%

For values 3.01% - 3.30%, plus 3.431p/1%

For values 2.95% - 3.00%, plus 2.941p/%

For values 2.90% - 2.94%, plus 2.451p/%

For values 2.89% and below, plus 1.961p/%

KG Deduction

-1.07 p/kg

Organic Premium

12.44ppkg

BASIC COST

£112.67 / month

HYGIENIC QUALITY

The hygienic quality of the milk is the geometric mean of the hygienic quality results over a period of two consecutive months ending with and including the month in respect of which payment is to be made. The percentage is applied to the raw milk value (butterfat, protein, base price and KG deduction)

Average Bactoscan '000/ml	Milk Price Adjustment
0-50	2%
51-100	0%
101-200	-4%
201+	-20%

SOMATIC CELL COUNTS

The monthly cell count value is the geometric mean of the valid cell count results over a period of three consecutive months ending with and including the month in respect of which payment is to be made. The percentage is applied to the raw milk value (butterfat, protein and KG deduction)

Three months' geometric mean cell count

Less than 200,000 = Payment of +2%

Deductions graduate from 200 (+2%) to 300 (+2%) at the rate of -0.04% per 1,000 SCC

Deductions graduate from 300 (+2%) to 400 (+1.2%) at the rate of -0.1% per 1,000 SCC

Greater than 400,000 = deduction of 20%

ANTIBIOTICS

The price for milk not complying with a valid antibiotic test is 125% of the value of the milk consigned for a first fail in rolling 12 month period.

150% of the value of the milk consigned for a second fail in a rolling 12 month period + £330 fixed costs*

200% of the value of the milk consigned for a third (or more) fail in a rolling 12 month period + £330 fixed costs*

STANDARD KG PRICE at 4% BUTTERFAT and 3.3% PROTEIN*

22.56ppkg = +8.403ppkg base +6.271ppkg butterfat +6.995ppkg protein +1.07ppkg KG Deduction +0.41ppkg bactoscan +0.41ppkg SCC +0.50ppkg volume bonus (1 million kg producer) Basic Cost -0.13ppkg +forecasted 13th payment 0.77ppkg.

VOLUME BONUS

Band	KGs/day	Bonus p/kg
0	0 - 1000	Nil
1	1001 - 1500	+0.20
2	1501 - 2000	+0.40
3	2001 - 2500	+0.45
4	2501 - 3000	+0.50
5	3001 - 3500	+0.65
6	3501 - 4000	+0.75
7	4001 - 4500	+0.85
8	4501 - 5000	+1.00
9	5001 - 5500	+1.10
10	5501 - 6000	+1.15
11	6001 - 6500	+1.20
12	6501 - 7000	+1.25
13	7001 - 7500	+1.30
14	7501 - 8000	+1.35
15	8001 - 11000	+1.40
16	11001 +	+1.60

ARLA SEASONALITY SCHEME

The 'Base' volume is determined by volume supplied in the months of August to December of the previous year divided by 153 days. The 'Seasonal' percentage is applied against raw milk value (fat, protein, base price & KG deduction)

	Seasonal %		Seasonal %
January	95%	July	105%
February	95%	August	115%
March	80%	September	125%
April	70%	October	115%
May	70%	November	110%
June	80%	December	100%

CHARGE FOR EXTRA COLLECTIONS

Every other day collection	No Charge
Every day collection	
Less than 8,000 Kgs / day	£20 / Collection
Between 8,000 Kgs - 11,000 Kgs / day	£20 / Collection
More than 11,000 Kgs / day	No Charge
Retailer aligned	No Charge

INDEPENDENT COLLECTION

A Premium of 0.20ppkg may be applied where a producer has entered into and at all times complied with the terms of the Independent Collection Agreement

EXTRANEOUS WATER

The Extraneous Water Adjustment is determined in accordance with the Producers Pricing Procedure. The volume of extraneous water determined will be deducted from that consignment

FPD	Adjustment (ppkg)
<509 - 503	-0.75
502 - 498	-1.25
497 - 492	-1.75
<491	-2.25

All elements above may be exchange rate dependent (excluding seasonality and volume bonus)

8. ARLA SEASONALITY SCHEME

- 8.1 The Arla Seasonality Scheme shall be calculated by reference to base litres and seasonal litres where the base litres volume in kilograms in any Month is calculated by multiplying the BADP by the number of days in the Month ("**Base Litres**"). The seasonal litres volume in kilograms shall be the total volume of milk supplied in the Month less the Base Litres ("**Seasonal Litres**").
- 8.2 The Arla Seasonality Scheme Adjustment for the purposes of clause 5.2(d) of Part A of Appendix 2 shall be calculated as:

$$\frac{\text{Raw Milk Value} \times \text{Seasonal Litres}}{(\text{Base Litres} + \text{Seasonal Litres})} \times (100 - \text{Seasonal Litres Monthly Percentage})$$

Where the "**Seasonal Litres Monthly Percentage**" shall be a % of the Raw Milk Value for the Month which is payable in respect of Seasonal Litres and shall be determined by the Board of Directors from time to time for that Month.

- 8.3 Any changes to the Seasonal Litres Monthly Percentage as determined by the Board of Directors under clause 8.2 above shall be notified to the members at least 12 months before becoming effective.
- 8.4 The Arla Seasonality Scheme Adjustment can be either a deduction or addition.

APPENDIX 7I: Muller Pricing Schedule

Issue Date: 28th April 2016Milk &
Ingredients

MÜLLER MILK GROUP PRICING SCHEDULE

(Applicable from 1 June 2016 until further notice)

MÜLLER MILK GROUP PRICE: 18.66 ppl

For milk of 4% Butterfat and 3.3% Protein, 1M litres pa, Bact <30, SCC <225

This price will then be adjusted as follows:

- * Butterfat - premium + 0.015ppl for each + 0.01% above 4.00%
- * Butterfat - penalty - 0.015ppl for each - 0.01% between 3.99% and 3.50%
- * Butterfat - penalty - 0.06ppl for each - 0.01% below 3.50%
- * Protein - penalty - 0.004ppl for each - 0.01% below 3%

HYGIENIC QUALITY PAYMENTS:

BACTOSCAN (Based on a 2 month geometric mean)			SCC (Somatic Cell Count) (Based on a 3 month geometric mean)		
Band 1	30,001 – 50,000	-0.25ppl	Band 1	225,001 – 250,000	-0.25ppl
Band 2	50,001 – 75,000	-1.25ppl	Band 2	250,001 – 300,000	-1.75ppl
Band 3	75,001 – 100,000	-2ppl	Band 3	300,001 – 400,000	-6ppl
Band 4	100,001 – 250,000	-4ppl	Band 4	6 th & Subsequent month between 300,001 – 400,000 without 3 months clear	-10ppl
Band 5	More than 250,000	-8ppl	Band 5	More than 400,000	-20ppl

ANTIBIOTICS:

The presence of antibiotics or other inhibitory substances will result in a payment of only 1ppl for the milk consigned on that day

VOLUME BONUS:

Collections between (Litres per day)	ppl
<2000	- 0.4
2000 – 2999	0
3000 – 4999	+ 0.1
5000 – 6999	+ 0.4
7000 – 8999	+ 0.7
9000 – 10999	+ 1.0
11000 – 14999	+ 1.3
15000 – 18999	+ 1.6
19000 – 22999	+ 1.9
23000 +	+ 2.2

SEASONALITY:

Graduated seasonality commences from March 2016 as notified 7 April 2015.

March, April, May & June

Graduated factor of -0.12ppl on each 1% of milk above 105% of your rolling 12 month average. Capped at 165% or -7.2ppl.

August, September, October & November

Graduated factor of +0.08ppl on each 1% of milk above 100% of your rolling 12 month average. Capped at 160% or +4.8ppl.

Deductions/additions apply on all litres supplied in the month.

EXTRANEIOUS WATER:

Failures at 504 or below will result in a payment of only 1ppl for milk consigned on that day

Other failures: <509

First failure: payment for milk consigned on that day	MMG Price minus 5ppl
Second failure (within 6 months): payment for milk consigned on that day	10ppl
Subsequent failure (within 6 months): payment for milk consigned on that day	2.5ppl

FORECASTING ACCURACY:

The following adjustments apply each month: Members can adjust predictions up to the last day of the month for the next month.

Scale	Penalty
- 10% to + 10%	-0.00ppl
> +/-10% to < +/-15%	-0.10ppl
> +/-15 % to < +/-20%	-0.30ppl
> +/-20 % to < +/-25%	-1.00ppl
> +/-25%	-1.75ppl

Penalty is charged at full litreage in the month

APPENDIX 7J: Tesco Cost Tracker Scheme

**Promar “Cost Tracker” from October 2015 to September 2016
including May to July 2016 Feed Fuel and Fertiliser Prices**

Cost Tracker Oct '15-Sept '16	Pence (ppl)
Variable costs	15.56
Overhead costs	11.53
Depreciation	1.85
Cost of milk production	<u>28.94</u>
FFF Adjustment (Feed, Fuel and Fertiliser)	-0.64
FFF Retrospective payment	0.39
Cost of milk production (COP) including FFF	<u>28.69</u>

Variable costs: Feed, AI, vet, bedding, dairy chemicals, seeds, fertilisers, silage, all the costs of rearing replacement heifers, and meeting costs of TSDG Livestock Code.

Overhead Costs: Milk related overheads, fuel, repairs, electricity, paid wages, water, office, insurance, rents, rates, interest. This includes a sum of £54,139 for the value of unpaid family labour.

Cost of milk production before FFF adjustment.

FFF adjustment: Impact of applying May to July 2016 feed, fuel and fertiliser prices (Anglia Farmers) to annual Cost Tracker

Retrospective payment: Payment to remove impact of applying May to July 2016 FFF prices retrospectively (Oct 15-March 16)

COP including FFF May-July 2016: The TSDG milk price.

APPENDIX 8A: Farm P Timeline

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		
Technological change (inputs)																							
Feeding	3.5 tonnes concentrate per cow										2 tonnes concentrate per cow												
Buildings and housing																							
Breeding	Pedigree Holstein																						
Milking											Holstein – Norwegian Red – Jersey crosses												
Fertility											Sold feeder wagon												
Production cycle (calving pattern)	All year calving																						
Waste management											Autumn calving												
Herd size / stocking rate	140												240										
Technological change (outputs)																							
Yield per cow											9k												
Change in buyer demands																							
New buyer																							Arla

APPENDIX 8B: Farm K Timeline

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Technological change (inputs)																								
Feeding																								
Buildings and housing															New cubicle shed									
Breeding																								
Milking																								
Animal husbandry and veterinary medicine																								
Fertility																								
Production cycle (calving pattern)																								
Waste management																								
Herd size / stocking rate	170	230-270 total																						
Technological change (outputs)																								
Yield per cow																								
Change in buyer demands																								
New buyer																								
Milk price																								

New calf sheds built

New cubicle shed

Rotary parlour

20/20 herringbone parlour

Introduction of 'scratchcards' / Estrofect detectors

Move to all year calving (4 year process)

Increased proportion of herd spring calving

300 Autumn calved, 120 Spring calved

(440 Autumn, 220 Spring)

420 [Uncle's farm stops dairy production > 160 cows added to herd]

660 cows

"Lower production than today"

Increase in output per cow (relative to current)

6800

Unigate (bought by Dairy Crest in 2000)

Waitrose (via Dairy Crest)

Waitrose / Dairy Crest demand level supply

Waitrose trials seasonal production

APPENDIX 9B: Farm E Timeline

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Technological change (inputs)																							
Milking	14/14 herringbone, 3 times a day																						
	2 times a day (due to labour)													20/20 herringbone 2 times a day									
Animal husbandry and veterinary medicine	Mobility scoring, condition scoring, hock scoring, lesion scoring, recording lying times, mastitis measurement, BVD scheme																						
Fertility																							
Production cycle (calving pattern)	Heat detection collars													RMS									
Herd size / stocking rate	All year calving																						
	c.110 (mixture shorthorns and Holstein)													180 (150 holstein, 30 shorthorn)									
														180 (90 holstein, 90 shorthorn, with plans to cut 45 shorthorns increase herd to 200)									
Technological change (outputs)																							
Yield per cow	10000+																						
Change in buyer demands	c.8,200																						
New buyer	Unigate (bought by Dairy Crest in 2000)													Sainsburys (via Dairy Crest)									

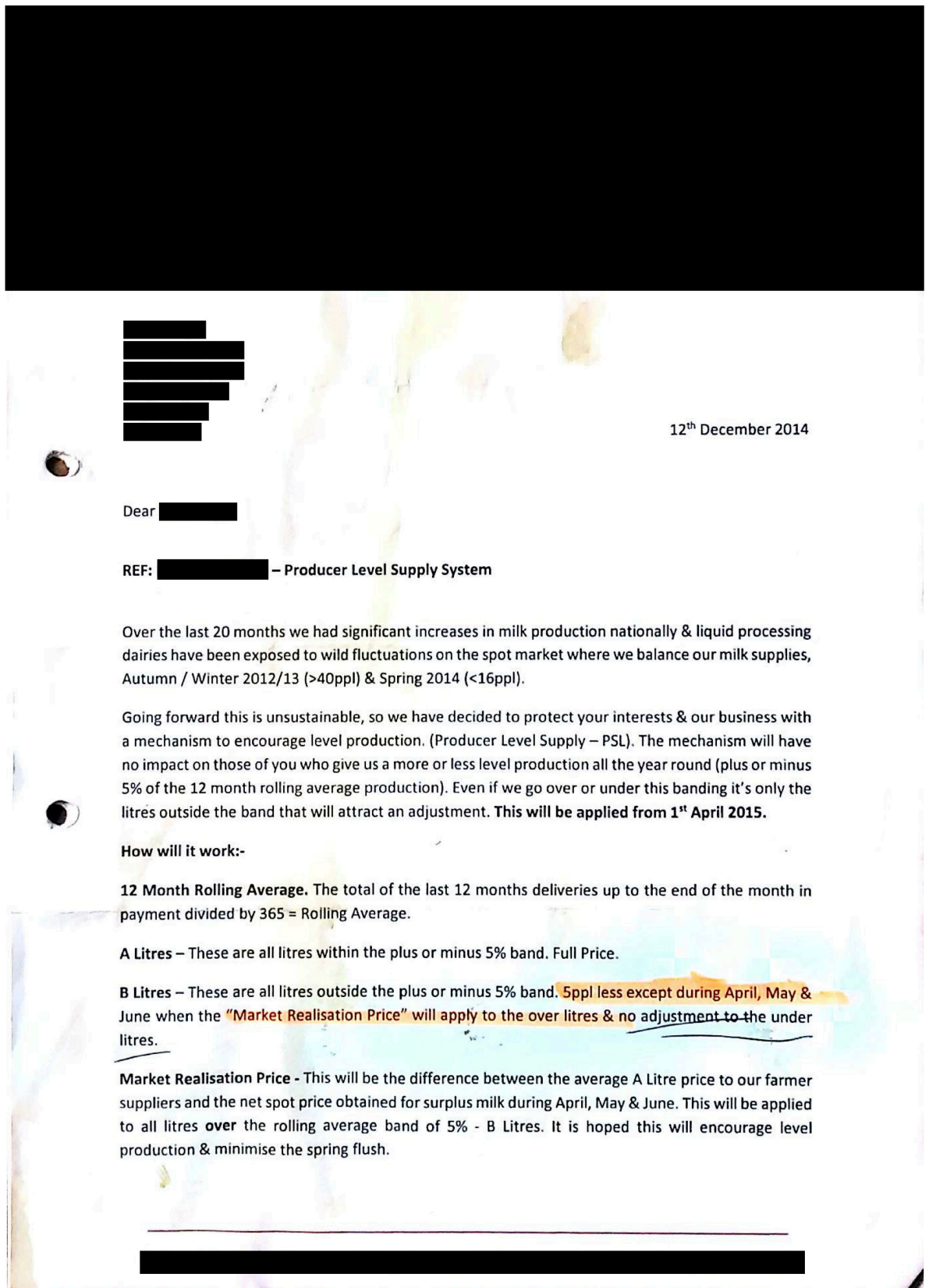
APPENDIX 9D: Farm C Timeline

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Technological change (inputs)																							
Breeding	Flying herd and all calves sold for beef																						
Fertility	Natural service bulls																						
Production cycle (calving pattern)	All year with summer emphasis		All year calving																				
Herd size / stocking rate	300																						500
Technological change (outputs)																							
Yield per cow	6.000																						9.000
Change in buyer demands																							
New buyer	Milk Marque		Wiseman		First Milk		Wiseman > Muller-Wiseman (merger)		Tesco (Muller)														

APPENDIX 9E: Farm B Timeline

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016		
Technological change (inputs)																									
Feeding	TMR and in parlour feeding																								
Breeding	Holstein																								
Fertility													Holstein – Jersey – Swedish Red Cross												
													Tail painting (RMS) and oestrous synchronisation in heifers												
Production cycle (calving pattern)	All year																								
Herd size / stocking rate	180																								
Technological change (outputs)																									
Yield per cow	6,500 – 7,000 litres																								
Change in buyer demands																									
New buyer	MD Foods (purchased by Arla (when)?												Tesco (via Arla											Arla	
																					8,400 litres		8,100 litres		

APPENDIX 9F: Farmer N Contract



APPENDIX 9G: Farmer J Contract



4. Production Balancing

The production balancing scheme is aimed at encouraging producers to deliver a level supply of milk throughout the year. The scheme first needs a producer's base daily litres to be created, this is done by dividing the total volume from the reference period 1st October 2012 to 30th September 2014 by the number of days in this period, 730 days. The reference period is fixed, but in the future can be varied at Wyke Farms discretion. A 24 month period has been used to average any seasonal anomalies.

The base daily litres figure is then multiplied by the number of days in a month to give a monthly production figure, to which a tolerance of +/- 5% is applied to give a monthly litreage range for base litres or "A litres". The percentage tolerance will be reviewed annually at Wyke Farms discretion. If actual production falls within this range, all litres will be paid for according to the price schedule. If actual production falls outside of the "A Litre" range there will be a "B litre" adjustment to reflect Market Realisation Prices.

The Market Realisation Price, (MRP) will be based on the prices that Wyke Farms buy or sell milk and milk product on the traded market for during the relevant month after taking account of, but not limited to, administration, transport, processing and foreign exchange costs.

If a producer supplies excess litres beyond the "A litre" range due to over-production the over-supply will be defined as "B litres" and paid for at the MRP. However in April, May, June and July if the MRP is higher than the standard litre price then the standard litre price will be paid on the "B litres". Any monetary surplus generated from this will be distributed in the month equally across the entire "A litre" supply.

A producer can appeal to have their base daily litreage figure increased or decreased if they have increased or decreased their production over the reference milk years. They can also appeal to change their base litres if they are planning in the future to increase or decrease production. The results of the appeal will be determined by Wyke Farms.